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LAWS OF DIMINISHING ENVIRONMENTAL INFLUENCE

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IT is a widely entertained belief, especially among reformers, philanthropists and many educators, that the force of environment is very great. This view may be the result of vague personal impressions, natural hope, kindliness of heart or perhaps at times professional and selfish interests. But do the facts of science support the expectant hope? Something is needed beyond dogmatic statements and wordy essays.

Experimentally and statistically there is not a grain of proof that ordinarily environment can alter the *salient mental and moral traits* in any measurable degree from what they were predetermined to be through innate influences. Yet there is naturally a feeling that environment must count for something, and from experimental zoology we know that in many ways its influence is very great. Surely the institutions, discoveries and inventions of civilization form an environment, the value of which from one point of view, is difficult to overestimate. How then can we bring relative order and laws out of the conflicting testimony? It is the purpose of this article by treating the subject from the comparative standpoint, and after a new method, to attempt to harmonize the diversified facts of inheritance and modification.

To distinguish between the relative importance of heredity and environment is not a mere academic question, but a practical one to be answered separately for each biological trait and always with an eye to comparative and proportionate influence. To say that both forces are important is to voice a platitude. To say that they are of equal importance is, in my opinion, to express a falsehood. To say that we can not unravel their interrelations is to turn our back, in a weak-

minded way, upon a question of far-reaching consequence. The disputes and confusions which have so long entangled the question I believe to be due to the failure to see certain practical, or common sense aspects—the failure to distinguish between environments which are greatly changed and those which are only slightly altered, between those from which escape is impossible and those from which such escape is relatively easy; the failure to distinguish between environments which are expected and those which are not, and, lastly, perhaps most important of all, the failure to distinguish between effects on higher and on lower types and tissues.

About ten years ago I became convinced through an extended analysis of the genealogical and personal data which exist in histories concerning the royal families of Europe that the influence of environment in creating mental and moral differences among human beings had been greatly overestimated. This conclusion was arrived at from various points of view. Statistical analysis not only supported a theory of germ-cell, or innate causation, but, what was more compelling, an intensive study of each separate family and each isolated group of close relatives brought out such sharp contrasts among the close of kin, such variations in types of mind and character, even when narrowly environed in point of time and place, that a recourse to heredity became forced upon me. The explanation from environment would not work.

This conclusion concerning the relatively slight or unimportant influence of environment as a modifying force on the higher human traits, I announced at the Chicago meeting of the American Psychological Association in 1901; since which time I have been constantly on the lookout for any investigations which might either confirm this belief or necessitate a change of faith. Several direct researches on human heredity have appeared which have been confirmatory in one way or another, and as far as I know nothing has been brought forward to disprove even an extreme belief in the predetermined nature of psychological differences; but it is not the human side of the question that I wish to discuss so much as the results of experimental zoology and botany and their significance to the student of man.

From time to time a vast array of experimental proof has come to my attention showing the profound effect of modification on plants and animals. The word modification I use in its technical sense as proposed by Lloyd Morgan to cover those changes which occur—*in the life time of an individual* and known to be directly traceable to some natural or artificial (usually artificial) change in its surroundings. These modifications are known to occur and may be easily observed or measured. Whether they are inherited or not is another question, and one entirely outside of the present thesis, for I wish to treat solely of

such modifications as are known to occur within the individual life at any time from conception to death or within a single generation. This will throw out of the question a hoard of cases where it is not quite clear whether the observed changes are the result of direct modification, in the true restricted sense, or are perhaps due in part to accumulated influences acting through several generations.

Confining ourselves then to a discussion of modification in the strict sense of the term, let us briefly survey the conclusions of experimental zoology, embryology and botany, and also experiments on regeneration, to see what lesson may be learned from the results of all this painstaking work. It will be of course impossible to treat of more than a fraction of the multitudinous results which have already been handed in as contributions to this young and rapidly growing branch of knowledge—experimental biology; but I believe that even a superficial survey will suffice to bring out my general contention.

The fact that ordinary differences in human environment, as shown in the history of royalty, appeared to alter the innate character and capacity for achievement but little, together with the fact that experimentally a great deal in the way of modification could be produced in the domains of zoology and botany, led me to suppose that there must be some inherent biological differences rendering tissues low in the organic scale especially susceptible to the molding of external influences.

This idea I advanced as an hypothesis in 1906 in the following words:[1]

> Among plants and the lower forms of animals, especially the invertebrates, many experiments have shown the remarkable changes which may be directly induced by changes in the outward conditions of life. *These are in general the more striking the lower we go in the scale of organic evolution, so that it may well be that in the highest attributes, namely, mental or moral, we can expect the least results from outward forces.* This hypothesis may prove a veritable generalization throughout the animal series.

In 1908[2] I expressed the same idea in the following passage:

> The profound modifications that may be induced in plants and the invertebrates by alterations of the surroundings are well known. But when one takes a survey of this whole question of modification, one sees that in general the lower we go in the scale of life the easier it is to effect the changes. It is significant that among vertebrates the modifications are largely associated with the integument, where cell-division is active and constant, and in a tissue that is not highly organized.

It is to offer the proof for this generalization that I now propose a survey of the whole question.

[1] "Mental and Moral Heredity in Royalty," New York, Henry Holt & Co., 1906, p. 294.

[2] Vol. V. American Breeders Association, Report of the Committee on Eugenics, p. 248.

I wish to state at the start that I have made an effort to collect notes bearing against this theory as well as for it. What I have here to offer is merely a report, almost statistical in its aim and methods, on the general significance of the total number of researches which have thus far been made touching upon modification. Original papers have been occasionally consulted, but the major portion of the notes are drawn from the well-known text-books dealing with these questions and have been rearranged, after a new scheme, under headings expressing in a general way phylogenetic rank. Text-books subdivide the experiments according to the external agents employed, *e. g.*, food, light, heat, gravity, etc., or discuss special types of modification in a disjointed way. The headings that I have made use of are: Plants, Low Metazoa, Mollusks, Crustaceans, Insects, etc., Fishes, Amphibians, Reptiles and Birds and Mammals, and finally Mental and Moral Traits.

It is of course impossible to say at times whether a certain species is higher or lower than another species, but surely we may expect agreement if we say that mammals are higher than birds, that the amniota are higher than the anamniota, and that amphibians are higher than fishes, and that all vertebrates are higher than the low invertebrates. It would be difficult to agree as to the relative rank of the highest of the invertebrates and the lower vertebrates, and difficult to compare the higher plants with low metazoa, but enough of relative rank will be admitted for the purposes of this generalization. Let us now see what chief modifications have been produced (that are nevertheless compatible with life) in these various organic groups.

Plants

The modifications in the plant world are so numerous and so striking that one scarcely needs to mention more than a small portion of all the experiments to show that plants are greatly influenced by their surroundings. For instance, plants may be made to grow ten or even twenty times as fast under optimum conditions as compared with their growth under the least favorable.[3] The Japanese dwarf trees show in a remarkable way the possibilities in this direction. The effect is due in part to a mechanical process which prevents the spreading of the branches, but the chief cause is found in poor soil and lack of nourishment.[4]

The great influence of gravity on the direction of the development of different parts of plants is also well known, as is their power of regeneration, where a single begonia leaf may produce a new plant, and even flowers if set in moist sand.[5] The great effect of differences

[3] C. B. Davenport, "Exp. Morph.," pp. 451–452.
[4] De Varigny, "Exp. Evolution," p. 71.
[5] Morgan, "Regeneration," p. 74.

in the amount or quality of heat, light, food, gravity, soil, manure and atmosphere may be easily verified.[6]

Low Metazoa

Among the low metazoa the influence of temperature, light and food is not so striking as among plants, still the changes may be called remarkable. For instance, the body-length of Echinus larvæ may be made, by raising the temperature, to increase about 25 per cent. of the average growth attained under a low temperature, while the arm-lengths in certain forms are at the same time increased from 200 to 300 per cent. If the number of larvæ of Echinus and Strongylocentrotus, which are growing together, be increased from under 1,500 per liter to over 3,000 per liter the mean length of the anal arms and the oral arms may be made to diminish from the figures 121.2 and 118.4 to 56.6 and 68.5, respectively.[7] No modifications like this have been induced among the higher vertebrates.

In the embryology of placental mammals the dorsal or ventral surface may be facing either up or down, right or left; all forces work out their destiny in disregard to the force of gravity. This force of gravity so important in moulding plants has been proved to be also very influential in the development of hydroids. Pieces of *Antennularia antennia* produce new stems that grow upward, and stolons that turn downward. Even if the piece is inverted the root arises from the lower end and the stem from the upper. Driesch observed in a species of *Sertularia* that whenever he altered the position of the piece the new growth changed its position so that the new part turned away from the center of the earth.[8]

The most remarkable of all experiments on low metazoa are the regeneration experiments. Since the exposed cells are subjected to a very considerable alteration of their normal environment, regeneration experiments may be considered as coming under the head of modification experiments. The power of regeneration possessed by worms and hydroids is so well known that only a passing reference is needed here. It is significant that among worms the tail will regenerate more than the head and that the reproductive organs, if removed, never regenerate at all, and the worm remains "incapable of reproducing itself."[9] This last fact is interesting as supporting the view that germ-cells are never reproduced from somatic cells of any kind, much less from

[6] Conf. Morgan, "Exp. Zool.," pp. 44, 265, 266. Vernon, "Variation," pp. 228, 245, 249, 262, 269, 282, 284–286, 312–314. C. B. Davenport, "Exp. Morphology," p. 480. E. Davenport, "Principles of Breeding," pp. 256–264.

[7] Vernon, "Variation," pp. 229, 296.

[8] Morgan, "Exp. Zool.," p. 266.

[9] Morgan, "Regeneration," p. 9.

the so-called "germinal epithelium," but are the direct descendants of cells that have never lost their germ-cell characteristics.[10]

Artificial parthenogenesis is also easily produced among the low metazoa, and this has been known for a long time. O. and R. Hertwig published in 1887 their experiments, which showed that various poisons might artificially induce segmentation in the eggs of echinoderms. Loeb carried the process further in 1899 and produced plutei from the unfertilized eggs of the sea urchins by raising the concentration of the sea water. "It was immaterial which substance was used to raise the concentration of the sea water, except for the fact that no substance could be used that injured the eggs too much."[11] Parthenogenesis may be initiated by such a variety of substances as chloroform, urea, sugar, salts and certain acids; but only in low forms of life. At least it is the legitimate inference that it is much easier to produce this effect among the simpler invertebrates. Experiments of this sort on the eggs of fishes are noticeable by their absence. Experiments on the eggs of frogs and Petromyzon have not, as far as I know, resulted in carrying the process beyond the segmentation stage. The experiments on insects which will be discussed under that heading have only a doubtful bearing on the present point, since parthenogenesis is among them more or less of a normal process.

Mollusks

Modification experiments on mollusks have been relatively rare in comparison with the lower invertebrates. This must be, to some extent, due to the practical difficulties which the experimenter would meet on attempting to modify an animal enclosed in a shell.

There is, however, much evidence to show that mollusks may be greatly influenced by their surroundings, at least as regards size. This especially concerns the question of the sizes of snails in relation to the extent of the media in which they are forced to live. The manner in which the volume of water affects the snail's growth is a matter of dispute and does not interest us here. The question for us is, how much are they affected? The answer is, that after about two months the snails grown under optimum environment were more than three times the length, or even five times the length, of those grown under the least favorable conditions.[12] Compare this with similar experiments on plants where the extreme variations artificially induced may be ten or twenty fold, and also with the experiments on the higher vertebrates where extreme variations resulting from any experimentally pre-

[10] For literature, see B. M. Allen, *Anatomischer Anzeiger*, Band XXIX., 1906, pp. 217–236.

[11] Loeb, "Dynamics of Living Matter," p. 167.

[12] Vernon, "Variations," p. 302. C. B. Davenport, "Exp. Morph.," p. 474.

scribed conditions are never anything like three to five fold in a linear dimension.

Other classes of modification experiments on mollusks are not so exact, but are perhaps worth mentioning. Vernon writes that "the permanent effects of temperature on size are probably very considerable among many of the mollusks," and quotes Cooke as stating that "a deficiency of lime, in the composition of the soil of any particular locality, produces very marked effects upon the mollusca which inhabit it; they become small and very thin, occasionally almost transparent." Unfortunately there is no statement that changes can be brought about in one generation, though very likely this is the case. Vernon says, in quoting Costa, page 314:

> On transferring young oysters from the English shores to the Mediterranean it was found that their manner of growth at once altered, and prominent diverging rays were formed, like those on the shell of the native Mediterranean oyster.

Regeneration experiments are numerous among the mollusks and indicate, as Przibram points out,[13] that these animals belong, with regard to their relation to the question of regeneration, in the middle rank between the lowest invertebrates and the highest vertebrates. He places mollusks in the fourth of six classes with respect to the power of regeneration, which can regenerate besides the tail, also limbs and organs of sense as long as the connection with the central nervous system is intact.

Crustaceans

There have not been many modifications experiments performed upon crustaceans except such as come within the more limited field of regeneration. There is evidence, however, that either different quantities of oxygen or differences in amount of the products of metabolism cause marked variation in the rate of reproduction of *Daphnia magna*.[14] There is also much evidence that among the Daphnias important changes in the life cycle may be artificially induced. These creatures may be made to continue parthenogenetic reproduction into the winter if kept in a warm place.

According to Irvine and Woodhead crabs can not produce their shells if they are allowed to grow in sea water from which chloride of calcium has been excluded, even if sulphate of lime and chloride of sodium are present. Chloride of calcium is absolutely essential for

[13] "Regeneration," Leipzig und Wein, 1909, Tafel XVI. Przibram here, in a chart, shows the general decrease in *regenerative power* with increase in phylogenetic and ontogenetic stages, but does not treat of other aspects of modification.

[14] Warren, *Q. J. Microsc. Society*, Vol. 43, p. 212, 1900.

[15] Morgan, "Exp. Zool.," pp. 312, 336.

the formation of the crab-shell. This, however, is not the case in the formation of the egg-shell of birds. To quote de Varigny, page 202:

> When laying hens are deprived of carbonate of lime by being shut into a room lined throughout with wood, without sand or soil, they are able to lay normal eggs, provided with the usual shell, if sulphate of lime is given them in their food. It follows that when the hen's organism does not receive carbonate of lime, as is usually the case, it is able to transform sulphate into carbonate.

De Varigny then says that other animals offer the reverse instance and alludes to the facts about the crab-shell, but does not see that this apparent contradiction is in any way associated with the great differences in organic complexity between the two animals, or that similar environmental changes have here produced a marked difference in the end product in the case of the lower creature and nothing in the case of the higher.

But these experiments are overshowed, and the great plasticity of this group of invertebrates is chiefly shown by the powers of regeneration which they possess. Experiments showing remarkable regenerative powers of the claws of lobsters, shrimps, crabs, crayfish, etc., are well known, and may be found described at length in any text-book dealing with the subject. In this respect they stand, according to Przibram, about on a level with the mollusks.

Insects

As soon as our review brings us to this highly differentiated group of invertebrates we see for the first time the fact that remarkable modifications are now chiefly associated with changes in the integument, especially changes of pigmentation. Profound modifications of a structural sort, and marked differences in body size are no longer met with.

We find, however, that changes in the surrounding temperature, and changes in food, affect the length of time occupied in the different stages of development of *Lepidoptera;* but in the end the result appears to be the same as under normal conditions. Morgan says: "The moth is identical with the normal," and at the end of his description of these experiments quotes the following: "What the insect gains in the larval stage it loses in the pupa stage."[16]

Some change in the size of the wings of the adult imago is another modification of an unimportant sort, and noted by Standfuss as a result of raising and lowering the external temperature during the larval period.

> For example, a pair of *A. fasciata,* of which the wings measured, respectively, 46 and 48 mm. across, produced three specimens measuring only 36 to 39 mm., when the larval stage was reduced to 68 to 87 days, and the pupal to

[16] "Experimental Zool.," p. 314.

15 to 20 days, by subjection to a temperature of 25° to 30°. On the other hand, some eggs from the same original pair of *A. fasciata*, which, though exposed to the same high temperature, developed more slowly—the larval period taking 142 to 163 days, and the pupal 25 to 31 days—yielding specimens having a wing measurement of 55 to 57 mm.[17]

It will be seen that these variations are not so great as those among plants or among snails.

There is, nevertheless, one very striking and curious kind of permanent modification possible among insects. I refer to the artificial production of royal couples among ants, and also to the production of queens among bees, both brought about by differences in the food supply. It would appear that the factor which determines whether a young female bee becomes a queen or a worker is whether she is, or is not, fed upon the royal food. In the case of ants this is not so clear, for the results may depend largely upon original differences in the eggs. Even if these transformations are brought about solely by environmental alterations they need not have much bearing on the present discussion, since this unusual possibility is of adaptive value to the species and may have been especially evolved and maintained. This is utilized by the insects themselves, "If an old queen dies, or if by accident all the prospective queens have been lost."[18]

Experiments which bring about changes in the life-cycle, and also those which produce parthenogenesis in insects which are normally sexual, can not be considered surprising. As to changes in the life-cycle, the case of the rose aphid is a good illustration. This insect produces parthenogenetically female offspring during the summer months, and normally on the appearance of winter begins to produce both males and females. This winter condition may be indefinitely postponed if the animals are kept in a suitable environment with plenty of food and water. Here we are not witnessing a profound modification, but only the failure of a certain normal change to take place in the failure of its normal stimulus.

Quite separate and different from this is the question of producing segmentation and growth in an unfertilized egg by some artificial chemical or physical means. This is called artificial parthenogenesis, and to have any special bearing on the present discussion must be produced in eggs that normally require fertilization by spermatozoa. The silkworm happened to be one of the first of the invertebrates to lend itself to this form of modification. "In 1886 Tichomiroff published the fact that the unfertilized eggs of the silkworm *Bombyx mori*, can be caused to develop by rubbing them gently with a brush, or by putting them for a short time into concentrated sulphuric acid."[19]

[17] Vernon, "Variations," p. 230.

[18] See Morgan, "Exp. Zool.," pp. 317–320; and Vernon, p. 287.

[19] Loeb, "Dynamics," p. 165.

We can not, however, consider this more than a slight alteration from the normal condition for two reasons. First, because the silkworm is closely allied to forms of moths in which parthenogenesis is normal; and second, because, as Loeb states, "Siebold had already mentioned, and Nussbaum confirmed his observations, that a small number of such eggs develop without these means." This is about the last we shall hear of artificial parthenogenesis, as our review takes us higher and higher in the organic scale of evolution. The results of such attempts as have been made to induce this form of modification among the vertebrates have been very unsatisfactory. Nothing can be made to develop beyond the segmentation stage.

Some experiments like those of Dorfmeister, Weismann, Eimer, Merrifield and Poulton show the direct results of changes in temperature, food and even the color of the surroundings; but these affect the character of the pigmentation in these normally highly pigmented forms, and we shall see, as we go higher in phylogeny, that pigmentation is one of the easiest characters to alter through environmental differences.

Regeneration experiments are naturally not numerous on the bodies of insects, for practical reasons, but their power to regenerate lost legs and wings falls in line with our generalization. The legs of the lower insects, like the walking-stick and cockroaches, will grow again if amputated, the legs of the higher insects, butterflies, ants, bees and wasps, not so well. Larval insects are placed by Przibram about on a par with adult mollusks, leeches and fishes, and a little behind Amphioxus as far as general power of regeneration is concerned. Insects in the final or adult stage are placed in the highest class along with mammals and birds, but since adult mammals and birds can not regenerate lost limbs[20] it seems as if further subdivision might have been made. Experiments which consist of grafting parts of different species on to one another are possible among insects at least during the pupal stage.[21] But the "integumentary organs" alone show successful union.

There is one way in which insects appear to show less modification than the vertebrates. Removal of the sexual glands from birds and mammals produces, as is well known, certain marked anatomical and physiological changes. These are supposed to be due to the cessation of an internal secretion which the gland normally produces. Removal of the sexual glands from insects does not cause changes in the secondary sexual characters. It seems fair to assume that this is because the sexual glands of insects do not produce any internal secretion. If

[20] "Experimental Zool.," "Regeneration," Taf. XVI. Die höchsten Formen regeneriern bloss Gewebsdefekte und ungegliederte einfache Hautbildungen (Schnäble, Insektenflügel). For aid in interpreting experiments on insects I am also indebted to Professor W. M. Wheeler.

[21] Morgan, "Exp. Zool.," p. 301.

this is true we should not expect any changes in the other organs of the body, since these other organs have not experienced any change from their normal environment. If, on the other hand, the environment is actually and certainly changed, as is the case when caterpillars are fed on different kinds of food, the variations associated with sex may, to a certain extent, be artificially induced.[22] It is very doubtful if the vertebrates will permit any such modification of sexual differences by changes in their diet.

Fishes

One of the first points noticed in looking over the results of modification experiments on fishes is that the total number of such experiments is significantly small. There is little to record that can in any way be considered striking or interesting as bearing on the present discussion.

If the under surface of flounders is exposed to light during the growth of the fish the side which is normally white will become pigmented like the upper side, though not so much so.[23] Here we see that what is perhaps the most striking modification produced in a fish is concerned merely in a change of pigmentation, which is probably always one of the easiest changes to bring about.

In hatcheries, it is sometimes desirable to retard the growth of fishes for commercial reasons. The experiments of Meyer, Earll, Rice and others show that lowering the temperature of the water lengthens the interval between fertilization and hatching to about a month. There are no further facts to show whether the fishes are permanently modified thereby. Presumably they are normal in the end, as is the case with retarded insects and frogs. Fishes show good regenerative powers and in accordance with their phylogenetic rank.

Fishes and frogs will not endure the high atmospheric pressure experiments that can be brought to bear upon low invertebrates without loss of life. Although the lower forms which submit to these high pressures (200 to 600 atmospheres) are only temporarily modified and afterwards regain their normal proportions,[24] the facts are significant as showing that higher protoplasm will not submit to the rude and abnormal treatment that the lower will. The higher protoplasm must have its accustomed environment and will not survive if it is ruthlessly forced into very unnatural surroundings.

Amphibians

Within this group one finds modifications brought about by differences in temperature, light, gravity, salt, electricity, atmospheric pres-

[22] Morgan, "Exp. Zool.," p. 437.
[23] Vernon, "Variation," p. 25.
[24] De Varigny, pp. 192–193.

sure and food. Experiments with differences of temperature cause merely differences in the rate of growth. These were first performed by Higginbottom some sixty years ago and have been repeated by O. Hertwig and by Lillie and Knowlton. Cold retards the rate of growth considerably; but the point here is, that if these animals continue to develop at all, the adult forms are not essentially different from the normal. Permanent differences in size, such as are produced in snails and especially in plants, are not effected among the amphibians by differences in amount of heat. Extra high temperatures, or those above the optimum, will often produce abnormalities or monstrosities, such as embryos with double heads or tails, but these do not live.

It is also noteworthy that the latitude for possible manipulation, by the use of high temperatures, is not as great here as among plants. Vernon says, page 228:

> Better instances, of the more and more unfavorable influence of increasing high temperature, are found among plants: as in them the optimum temperature is much further removed from the "maximum" temperature (the highest temperature at which growth can take place at all) than it is in animals.

Light has but little effect upon the growth of amphibians.[25] Gravity, on the other hand, has considerable demonstrable influence on cleavage during the very early stages of the developing egg.[26] This influence of gravity on the growth of amphibians should be contrasted with its far greater effect on plants and hydroids, and also with its probable effect on the developing embryos of mammals, which must here be very slight, if any, judging from the haphazard nature of placental attachments. Gravity may of course play a certain rôle in mammalian embryology in the very youngest stages. Investigation of this question would in the nature of things be very difficult. But even if it does, its influence in the later stages is certainly very slight and, so far as we can see, negligible. My argument is that the modifying influence of gravity is less in higher organisms than it is in lower, and less in older stages of development than it is in younger.

The effect of changes in salinity and density of the water in which frogs are developing are in general similar to those involving changes in the temperature. Retardation of the *rate* of growth may be brought about, but the evidence is lacking to show that the animals are any different in the end. It is of interest to note that in this connection there is something that might be thought contradictory to the generalization which I am making. H. de Varigny who has himself experimented upon the effect of introducing common salt into fresh water where tadpoles are growing, states[27] that it is easier to accustom tad-

[25] Morgan, "Exp. Zool.," pp. 262–263. Vernon, p. 249.

[26] Morgan, "Exp. Zool.," p. 267.

[27] "Exp. Evolution," pp. 189–190.

poles of three weeks of age to withstand an excessive amount of salt than it is younger larvæ.

But it is not my contention that younger stages of ontogeny may not be more sensitive than older ones to certain abnormal external conditions. A young chick is more sensitive to cold than an older one. My contention is that if we wish to produce a modification, which is nevertheless compatible with life, we can succeed best with the younger stages of development and with lower organisms. In this case no life-compatible modification was produced in either case. The younger tadpoles modified, but died. The older ones did not modify, but continued their development in a normal way. The real reason of the difference may here have been that the vital cells of the older tadpoles were better protected by the outer covering (ectoderm), so that the interchange of fluids (osmosis) worked more gradually in these vital cells. In just the same way the cold injures the young chick more, because from the absence of feathers, the same degree of cold reaches his vital organs more suddenly.

Experiments involving the effects of electricity on the growth of frogs' eggs are not of any special significance. They produce changes in the arrangement of the pigment and sometimes abnormal cleavage, or abnormal development. Differences of atmospheric pressure (presumably really differences in the amount of oxygen absorbed by the water) cause differences in the *rate* of growth. The researches of Rauber[28] show that

> At a pressure of three atmospheres no growth occurred. At a pressure of two atmospheres growth was slower than at the normal pressure. At three fourths of an atmosphere death generally occurred. Thus the optimum condition of oxygen tension is near the normal of the atmospheric.

This certainly can not be considered a surprising discovery, nor have the experimenters produced any appreciable modification on amphibians by means of differences in the amount of oxygen.

The development of tadpoles can be considerably retarded by scanty feeding, so that they may be kept in the gill-breathing stage for over a year; but if they survive they still retain their potentialities for becoming normal adults. This is shown by an interesting experiment of de Varigny's. He describes it thus:

> I have myself kept toads in the tadpole state for over two years, merely by feeding them very scantily. They were born in the spring of 1889, and remained all the time in an aquarium in the laboratory, having water enough at their disposal, being always sufficiently provided with aquatic plants, and enjoying heat enough; but it can by no means be said that their evolution was arrested by the cold of winter, as often happens in mountain ponds, when the cold of autumn sets in before the tadpoles have achieved their development, so that they become frogs or toads only in the course of the following year. In the

[28] Davenport, "Exp. Morph.," p. 306.

case of my tadpoles, it seemed that the completion of development was due to my imprudently feeding them in spring of 1891 on the very substantial flesh of their congeners; and in the course of some three weeks at most the limbs were evolved, the long tail disappeared gradually, the very color and appearance of the skin underwent considerable change, and my superannuated tadpoles became toads at last.

Modifications of this sort are shown in the experiments of Kammer.[29] *Salamandra atra* acquires yellowish white spots through higher temperature and moisture. Low temperature and dry conditions make *Salamandra maculosa* more black in color with a diminution of the yellow spots.

The amphibians show good powers of regeneration, but their faculty in this direction is neither more nor less than is warranted by their position in the phylogenetic scale. This is well indicated by Przibram.[30] In their younger and lower types they belong in the fourth class of animals, or those which can regenerate not only the tail, but also limbs, sense organs and other portions of the body as long as the central nervous system is not removed. More adult and higher types lose some of this power and then may regenerate the tail only or only certain tissues.

The general conclusion from all these experiments on amphibians involving artificially induced changes in the condition of temperature, light, gravity, salt, electricity, oxygen and food is that when we arrive as high in the phylogenetic scale as the amphibians very little can be done to permanently modify the predetermined forces of the germplasm. As among fishes the most striking permanent changes are concerned with the pigmentation.

Reptiles

In powers of regeneration the reptiles show their higher phylogenetic rank. The lizard can regenerate the tail, but not the limbs. It is interesting that the new tail is not composed of bones, but is a cartilaginous tube attached to the half of the broken seventh caudal vertebra.[31] Snakes and turtles will not regenerate their tails.

Modification experiments, other than those concerning regeneration, are not numerous or suggestive. I find only reference to the well-known pigmental response of the chameleon.

Birds

As we ascend the scale we not only find that modification experiments are less striking in character, but also find fewer experiments recorded. Noteworthy modifications of birds are almost entirely con-

[29] *Arch. für Entwickelungs Mechanik*, XVII., pp. 165–264.

[30] "Regeneration," Leipzig, 1909, Taf. XVI.

[31] Morgan, "Regeneration," pp. 6, 198.

cerned with questions of their plumage, and especially with the coloration of the same. A good summary of this knowledge is contained in Vernon.[32]

> The effects of certain foods on the plumage of birds is well known to bird fanciers. Thus, hemp-seed causes bull-finches and certain other birds to become black. Cayenne pepper mixed with the food changes the yellow color to an orange red. This color change can only be effected by feeding the very young birds; with adults there is no effect whatever. Sauermann found that all races are not equally susceptible to the abnormal diet, some being changed to crimson, others to a beautiful orange, whilst others remain absolutely unaffected. He found also that canaries are not alone in their susceptibility, for on feeding some white Italian fowls, eight weeks old, with the pepper, orange stripes appeared on the breast feathers, and the breast had become red. One other fowl also developed a red breast, but the remaining ten showed no change whatever. The doses of Cayenne pepper given were enormous (50 gm. daily), so that the conditions were absolutely unnatural.

More remarkable than these observations are the facts ascertained by A. R. Wallace, and communicated by him to Darwin. Thus he states that

> The natives of the Amazonian region feed the common green parrot (*Chrysotis festiva*) with the fat of large Siluroid, fishes, and the birds thus treated become beautifully variegated with red and yellow feathers. In the Malayan archipelago the natives of Gilolo alter in an analogous manner the colors of another parrot, namely, the *Lorius garrulus*, and thus produce the *Lori rajah* or King Lory.

Artificially produced alterations in the pigmentation of American birds are shown by the experiments of C. W. Beebe.[33] These experiments demonstrate that the effect of a very humid atmosphere is to increase the dark pigment in the three species studied, namely, the wood thrush, the white-throated sparrow and the inca dove. Beebe mentions that in a state of nature, where the dark forms have been isolated by geographical barriers (and where, of course, natural selection, or other adaptive forces, have been at work for generations), other structural differences are to be found. "With this darkening of the skin structure is frequently correlated a distinction in point of size, either of the body and skeleton as a whole or superficially, as of larger or shorter feathers of the wings or tail." Since Beebe mentions no structural changes of the body as a result of his *artificially* produced humidity, one infers that the changes were confined to the pigmentations.

In the early stages of embryogeny, heat and light, especially heat, affect the rate of development,[34] but there is nothing, as far as I know,

[32] "Variation in Animals and Plants," pp. 293–294.

[33] Amer. Breeders' Assn., Vol. V., 1909, pp. 392–394.

[34] Morgan, "Exp. Zool.," pp. 261, 262, 459; and Davenport, "Exp. Morph.," p. 459.

to show that the birds when adults exhibit any variation as a result of all these manipulations.

It is noticeable that the range of temperature (within which any growth is possible) is more restricted for birds than it is for the lower animals.

The comparative difficulty of producing a modification in birds is exemplified, in another interesting way, in the elasticity which the hen possesses of producing a shell when carbonate of lime is absent. This was referred to earlier in this article when commenting on the modification produced in crab-shells.

Regenerative powers, as is well known, are very slight in birds. In two forms at least, the stork and the fighting cock, the beak will regenerate. This fact[35] has been discussed by Weismann and others in connection with the theory of "regeneration and liability to injury," but it does not appear to have been noted that the beak is an integumentary structure and that of all tissues the epidermis is one of the easiest to modify. Neither the wings nor feet of birds will regenerate.

Mammals

In mammals, as in birds, the chief modifications are concerned with the skin and its appendages.

There is good evidence that changes in climatic surroundings directly affect the color of the hair of some of the mammalia, though at the same time it is evident that others remain unchanged. To a certain extent the white winter coat of the Hudson Bay lemming, and changes in the coloration of hares and rabbits, must be due to direct influence of temperature.[36] Many arctic animals, however, do not change their coat color with the season. Changes in the amount and quality of the hair of various quadrupeds on transportation from one part of the world to another are abundantly recorded.[37]

Other well-known modifications associated with the integument are thickening of the human epidermis by pressure and friction, and darkening of the skin by the action of the sun's rays. The effect of sunlight on the higher animals appears, however, in regard to the vital functions, to be merely superficial. We have, for example, many instances where prisoners have spent long lives in darkness or have perhaps been freed after years of confinement and have then resumed their normal activities. Working mules have been kept in mines for long periods of time, as much as twenty years, "and beyond temporary sensitiveness of the eyes no effect was perceptible."[38]

[35] Morgan, "Regeneration," pp. 95, 97, 106.
[36] Vernon, pp. 243, 330, 331. Morgan, "Exp. Zool.," p. 13.
[37] De Varigny, pp. 88–91.
[38] E. Davenport, "Principles of Breeding," p. 244.

On the other hand, it is said that arctic explorers experience sluggishness of the mind during the long winter night, as a direct result of the darkness. I do not know how far this is true, but in order to show that this is contradictory to my generalization it would be necessary to prove that the effect is greater upon the minds of men than upon the minds of domestic animals, and greater upon the minds of the leaders of the parties than upon the crews. It would seem improbable that such is the case. Moreover, I am informed by Captain Bartlett of the *Roosevelt,* that if the men are busy with duties, and if their minds are occupied to the usual extent, no such depressions occur.

With regard to the influences of direct contact on different tissues, I have already noted that pressure produces an easy modification upon the outer skin. Prolonged pressure will also produce noticeable changes in the shapes of growing mammalian bones, but it is probable that even greater modifications might be produced on the skeletons of lower animals. Normally, bone like the epidermis is being constantly remade by proliferation of young cells from the growing layers. In this respect it differs from nerve tissue, the cells of which cease division in early embryonic life.

Boas has recently announced that he has found evidence that the head forms of the children of Hebrew and Sicilian immigrants who come to the United States tend to approach the American type, as a direct result of some mysterious influence of the environment. This he assumes to be of suggestive value to the psychologist and sociologist. He fails to take into account the great anatomical and embryological differences between bone tissue and cerebral nerve tissue. The real deduction from all this work (if indeed it should be confirmed) is that it is easier to modify a bone than it is a brain.

If we consider the effects of different kinds of feeding upon higher animals, as contrasted with the lower, it is evident that the modifications brought about in this way are much less striking among the higher. The linear dimensions of lower organisms may be altered from two to twenty fold. On the other hand, there appears to be an inherent tendency for mammals to grow to a certain definite size within narrow limits. Minot[39] has shown that the *rate* of growth of guinea-pigs may be artificially altered, but that there is nevertheless a strong tendency for guinea-pigs to grow to a certain size, and that they make up in later stages what they lose in the younger; or if there is an extra increment in the younger stages this is compensated for, later on. This is confirmed by F. B. Sumner for the white mouse.[40] Our general knowledge concerning human twins supports this view. Very fre-

[39] "Senescence and Rejuvenation," *Journal of Physiology,* Vol. XII., No. 2, 1891.

[40] *Jour. of Experimental Zool.,* 1909.

quently twins differ much in size at the time of their birth, even when they are afterwards known as "identical twins" and are difficult to distinguish apart. The puny twin must have been at a disadvantage during uterine life, but this has no permanent effect and is all made up in the end.

It is well known that lecithin given in small quantities in the food will increase the rate of growth of mammals. But it has not been shown, as far as I know, that the ultimate sizes of the adults are thereby made to vary. Let us see what proportionate change in rate of growth has been effected by experiments of this sort .

The communications of Hatai[41] shows that guinea-pigs, rabbits, dogs and rats, after from one to two months' treatment with lecithin, have their rate of growth so altered that the amount of growth is increased from 1.29 to 4.60 times the normal growth during this period. The total weight of the animals is, however, but slightly increased. The animals are merely rendered about two to five per cent. heavier than they normally would have been during the same period of time. Hatai, in referring to the experiments of Danilewski on the eggs of frogs, states that frogs' eggs placed in water containing 1 to 1,500 by weight of lecithin, gained in fifty-four days, 300 per cent. more in weight than those reared in ordinary water.

This would give one the impression that the changes were about the same in ratio for mammals as for tadpoles since the amount of actual additional growth in mammals may be fully three times as much with lecithin as without it. On looking up Danilewski's[42] original paper I find, first that the proportion of lecithin used was not 1 to 1,500 but 1 to 15,000 for the frogs; and second, what is more important, that the gain of 300 per cent. refers not to the portion gained during the interval when lecithin was given, but to the total weight of the organisms. Thus tadpoles may be made to vary 300 per cent. of their *total weight,* mammals about two to five per cent. At the same time it seems that the tadpoles are nearly doubled in linear dimensions. It is evident that the mammals are but slightly altered in linear dimensions.

Thus the experimental work of biologists indicates, when we take a comparative bird's-eye view of modification, that environment will be found to be working upon human brain and nerve tissue at its minimum of efficaciousness. Let us see what direct statistical experience has to say on this important problem.

Mental and Moral Traits

The direct researches which have essayed to separate the environment and heredity factors in the higher human traits, and measure

[41] "The Effect of Lecithin on the Growth of the White Rat," *Amer. Journal of Physiology,* 1904.

[42] *Comptes Rendus,* CXXI., 1895.

approximately their relative influence, are all in substantial agreement. The first light thrown on this question comes from Galton's "History of Twins,"[43] published as long ago as 1883. The traits under discussion were physical resemblances, diseases, mannerisms of action, mental disposition, temperament and tastes. The data are not given in completeness, nor in statistical form, but the conclusion seemed to him warranted that, as regards such mental and physical differences as were under discussion, nature prevails strongly over nurture, within the limits which Galton is careful to assign to the latter. This belief was arrived at from a comparison of thirty-five pairs of very similar twins with twenty pairs of dissimilar twins.

Those twins who were similar when young remained so in general, as they grew older; but more significant than this, there appeared to be no tendency for similarities in education and home life to render those originally unlike any more similar with advancing years. The conclusion from Galton's "History of Twins" seemed to be that if the environmental differences are slight no appreciable effect is produced at least upon innate mental differences which are themselves comparatively slight or unimportant, such as differences in tastes, temperament and disposition. This would of course not prove that the more important human differences, such as are represented by success or failure, vices and virtues, are not profoundly modified by environment if the differences in surroundings are considerable.

The history of royalty offers just these remarkably wide differences of an environmental nature. This is somewhat surprising because one might assume that the surroundings would be uniformly superior, as all are of the highest social rank. But for various reasons the individuals have developed under the greatest variety of good and bad influences as regards the atmosphere of their home life, their educational advantages, and opportunities for distinction. Besides, they have lived in different countries and in different eras. Yet, in spite of the fact that the environments show wide variations, these appear to be negligible factors in the production of successful achievement or in the creation of virtuous or vicious types.

That successful achievement is almost entirely due to differences in germ-plasm and is little influenced by environment is the necessary conclusion from the complete analysis of two separate groups of royalty. One of these is the great interrelated group of 3,312 distinct persons in Lehr's Genealogy. This book contains many repeated names, because the same individual appears as an ancestor of different lines, owing to intermarriages. Thus the total number of cases for statistical purposes is much greater than 3,312. It is in fact 32,768, for this book contains eight "families" with 4,096 in each family. Out of the 3,312 different persons there were sixteen who came up to

[43] "Inquiries into Human Faculty," 1883, pp. 216–243.

a certain objective standard of distinction and 3,296 failed to do so. The environmental influences must have been mostly distributed at random throughout the group. Yet this did not cause any random distribution of the distinguished persons. Fifteen out of the sixteen were closely related to other distinguished persons.

The second group of royalty contained all the close connections of twenty-three reigning historical dynasties. This group was obtained by a different method, but in part overlaps the other group. Here detailed analysis was made not only of the question of intellectual distinction but of mental and moral variations. Environment was shown to be of little or no consequence in the production of important differences.[44]

The third research to appear on the problem of nature *versus* nurture is that of E. L. Thorndike,[45] on the origin of mental differences among children attending the public schools in the city of New York. Thorndike, like Galton, used the records of twins to support his argument, but went into the matter with far greater scientific analysis and published all the details of his measurements. He presents:

> (1) The results of precise measurements of fifty pairs of twins from 9 to 15 years old in [eight physical and] six mental traits and (2) their bearing upon the comparative importance of heredity and environment as causes of human differences in intellectual achievement. They will be found to give well-nigh conclusive evidence that the mental likenesses found in the case of twins and the differences found in the case of non-fraternal pairs, when the individuals compared belong to the same age, locality and educational system, are due, to at least nine-tenths of their amount, to original nature.

In concluding his research Thorndike says:

> It shows such likeness and differences in environment as act upon children living in New York City and attending its public schools are utterly inadequate to explain the likenesses and differences found in the traits measured, and are in all probability inadequate to explain more than a small fraction of them. The arguments concerned the lack of differences in the amount of resemblance (1) between young and old twins, (2) between traits little and traits much subject to training and (3) between mental and physical traits, and also the great increase in resemblances of twins over ordinary siblings [brothers and sisters].

Thorndike's research appears to be very conclusive and confirmatory as far as it goes. Of course one might contend that after all the

[44] For the arguments which support this belief see POPULAR SCIENCE MONTHLY, August, 1902–April, 1903 (Vol. LXI., pp. 375, 453, 455, 457, 507, 508; Vol. LXII., pp. 84, 268, 423, 426, 497, 500–503). Same in reprinted form, pp. 9, 17, 19, 21, 26, 27, 41, 65, 73, 76, 79, 82–85. Additional arguments of a generalized nature may be found in "Mental and Moral Heredity in Royalty: a Statistical Study in History and Psychology," New York, Henry Holt, 1906, pp. 276–298. The arguments drawn from intensive analysis of small groups may be found on pp. 6, 56, 81, 119, 123, 170, 222, 224, 231, 246–247, 248–249, 253–254, 271.

[45] "Measurements of Twins," *Arch. of Philosophy, Psychology and Scientific Methods*, New York. The Science Press, 1905, pp. 64.

environmental differences which are experienced by children in the public schools of New York are not very great and that the traits concerned are not really important ones. Such important traits as normal healthy body and mind for a long life of valuable achievement, and a clean bill of character, can only be determined as present or absent, in their varying amounts, after the race of life has been completely or nearly run, and the records of success or failure, of distinction or obscurity, of vices or virtues, have been left behind. The boy is father to the man but our knowledge of biometry already teaches us that this does not mean identity; it merely means a correlation.

The study of children may lead us to wrong conclusions for other reasons. It has already been shown in this article that, other things equal, the young can be more easily affected by surroundings than the adult, and also that there is a great tendency for the higher organisms to equalize in time what they have gained or lost in youth, and to grow after a predetermined plan. For these reasons even the discovery of actual modifications produced among children would not show that the grown men and women, who will be freer to pick and choose their congenial environment, will not follow the same paths that they otherwise would have done.

Pearson and his pupils have recently attempted, by the comparative study of children, to differentiate between the relative influence of heredity and environment. Their results are confirmatory for the special traits studied. In a memoir on vision and sight[46] the authors write as follows, with regard to the effects of environment.

> As far as the admittedly slender data of this first study reach, there is: (1) No evidence whatever that overcrowded, poverty stricken homes, or physically ill-conditioned or immoral parentages are *markedly* detrimental to the children's eye-sight. (2) No sufficient or definite evidence that school environment has a detrimental effect on the eye-sight of the children.

At the close of the paper the authors make the surprising statement that their own research is "the first eugenic study which has endeavored to compare the inheritance and environment factors. We anticipated finding them to be far more comparable in magnitude." If the authors had read a little of the earlier researches on the question of the relative influence of heredity and environment they would neither have spoken of their own eugenic study as the first nor have expressed wonderment at the result.

In "The Relative Strength of Nurture and Nature," Ethel M. Elderton[47] analyzes the above investigation on the eye-sight of children, and also her own study on "The Influence of Parental Occupation and

[46] Amy Barrington and Karl Pearson, "A First Study of the Inheritance of Vision and the Relative Influence of Heredity and Environment on Sight," London, 1909, pp. 61.

[47] "Eugenics Laboratory Lecture," Series III., London, Dulau & Co., 1909.

Habit on the Welfare of the Offspring," together with a research of Heron's on "The Influence of Home Environment and Defective Physique on the Intelligence of School Children." These researches "show clearly the small influence of environment." The author on page 28 writes:

> The whole subject of the influence of environment, owing to its complexity, is a fascinating one, partly because we are only just beginning to apply modern statistical methods to this side of eugenics, and the results we obtain are often very unexpected, perhaps we may say wholly contrary to current belief.

That they are contrary to current belief I do not deny, but to say that they are unexpected shows little grasp of the whole biological question of modification or knowledge of results of earlier workers. In fact it will be very surprising if any one succeeds in demonstrating an important environmental control acting on psychological differences, exhibited in mental and moral traits. All the evidence that we possess renders it highly improbable that any of the ordinary differences in human environment, such as riches or poverty, good or bad home life, have more than a very slight effect in modifying these complex and high organic functions the improvement of which is the hope of the altruist and the reformer. Not only do the collected facts indicate as much, but the reasons for the same are not difficult to understand if we consider the laws of diminishing environmental control.

Each organism, whether high or low in the scale of evolution, has from the time of conception and beginning of cell-division and segmentation onward through embryonic and post-embryonic life an *expected* environment. In other words, it *expects* to develop and live under conditions which are essentially similar to those which surrounded its immediate ancestors at each stage of *their* career.[48]

If the expected environment is altered, then the modification which will accrue will in general diminish, (1) in proportion as the change from the expected is less and less in amount. This will follow as a

[48] Since writing this I have received a letter from a distinguished student of heredity containing some remarks on the question of environment *versus* inheritance. This gentleman, like so many others, does not see that although a result may be due to a complexity of forces we may, nevertheless, measure the relative value of the different components. I refer him, for his encouragement, to the opening chapters of any text-book on physics where the "Laws of Motion," "Parallelogram of Forces" etc., suggest helpful analogies. One illustration which the correspondent gives may serve to make my own standpoint clearer if I answer it here. He says "the question of whether nature or nurture plays the greater part does not arise. As well might we ask whether the locomotive or the steam plays the greater part in transporting the train." My answer is, that by all the needs of a suffering humanity or the development of a rational understanding of the present, past or future of this same species, *Homo sapiens*, the question does arise; and second that the illustration from the locomotive will do as well as any other. Here, it is the locomotive, not the

matter of course. Its only interest for us lies in the fact that most alterations in the surroundings that are brought to bear upon human beings are probably not very great in actual differences. They are at least not great in comparison with the experiments of the botanist and zoologist. (2) Environmental influence diminishes with increased phylogenetic rank. (3) Environmental influence diminishes with the evolutionary rank of the tissue affected. (4) Environmental influence diminishes in proportion to the age of the tissue affected. The contents of this paper have been chiefly brought forward to support these second, third and fourth laws. Artificial modification then appears to be easiest upon tissues that are either young or simple, or in a condition of cell subdivision and growth. It must be remembered that the brain-cells, even of a child, are, of all tissues, farthest removed from any of these primordial states. The cells of the brain ceased subdivision long before birth. Therefore, *a priori,* we must expect relatively little modification of brain function. We next have to consider the question of the possibility of escape on the part of the organism from a novel and perhaps unwelcome environment into its natural one again. (5) Environmental influence diminishes with the organism's power of choice. This may be the chief reason why human beings, who of all creatures have the greatest power to choose the surroundings congenial to their special needs and natures, are so little affected by outward conditions. The occasional able, ambitious and determined member of an obscure or degenerate family *can* get free from his uncongenial associates. So can the weak or lazy or vicious (even if a black sheep from the finest fold) easily find his natural haunts.

In psychological matters we are dealing with a totally different class of cases from the zoological experiments referred to in this paper. It is a point often forgotten, yet one that should be constantly born in mind, that there are these two kinds of environment from the standpoint of an organism. There are surroundings from which there is no escape, let the creature try his best, and there are also environments from which escape is possible if the inheritant desires impel it. All the modifications on lower animals alluded to in this article are of the first kind, or have been brought about by imposed conditions from which there was no escape. Psychological environment can scarcely be placed in the same category. Therefore the inference is that not only is the brain little influenced by surroundings owing to its high

steam, which is the essential thing. The purchasing agent pays the highest prices for the very best machine because he knows that having got his best machine he can easily get his fuel and his water. *He expects* to get these. These form the expected environment which may differ some in quality and effect, but after all, from the practical standpoint, the essential thing is the quality of the machine. It is just so with the human mind. Nature is the great decider because nurture is expected.

organic rank, but also because most of the varying environments within any one civilization are not absolutely imposed upon the individual, as are experiments upon the lower organisms. This is not meant to imply that differences between one historical age and another, or any other imposed environment from which there is no escape, may not be found of considerable importance in relation to certain sociological and historical facts. For instance, the total number of eminent men in western Europe probably increases too rapidly from the fourteenth century to the sixteenth not to be in part due to the force of circumstances.[49] Also I have statistics in the course of compilation which indicate that there is evidence that women are advancing in noteworthiness of achievement in the United States with each elapsed decade. These imposed and unescapable conditions, which change with the course of history and affect entire races or great groups of people, must be clearly distinguished from the class of environments that exist within any one age and in any one state of civilization.

There are doubtless other ways in which man and other mammals are directly modified by their environment in an essential and lasting way, but to enter into a discussion of these questions is useless in connection with this generalization. Such are the modifications produced by poisons, diseases of a bacterial or other nature, which the individual accidentally encounters. The necessary knowledge has not yet been gained for any generalization, from a comparative point of view, in regard to these complicated processes, so that we should be able to say that these changed conditions affect higher organisms more than lower Moreover, the same poison may be for one kind of protoplasm a great change and for another a slight one, and we have already seen that the proportionate amount of change in the outward conditions is necessarily of prime importance in determining the end result.

These chemical questions do not fall within the literature contained in text-books of experimental zoology, which, to review and rearrange has been the chief purpose of this article. The entire analogy of such experiments, as well as the results of special studies on the relative influence of heredity and environment, can lead to but one conclusion, and that is, that the value of modification diminishes as evolution proceeds.

I know that to generalize is dangerous and exceptions may be found which seem to conflict with the laws or principles which are here set forth, but often apparent exceptions find explanation in the light of further knowledge. I put these laws forth with some hesitancy, yet feel that enough is known to take a step beyond hypotheses and trust that the future will confirm their essential truth.

[49] This would be the conclusion from Cattell's "Statistical Study of Eminent Men," POPULAR SCIENCE, February, 1903, and Ellis's "Study of British Genius," p. 12.

THE LEADING SCHOOL OF TROPICAL MEDICINE

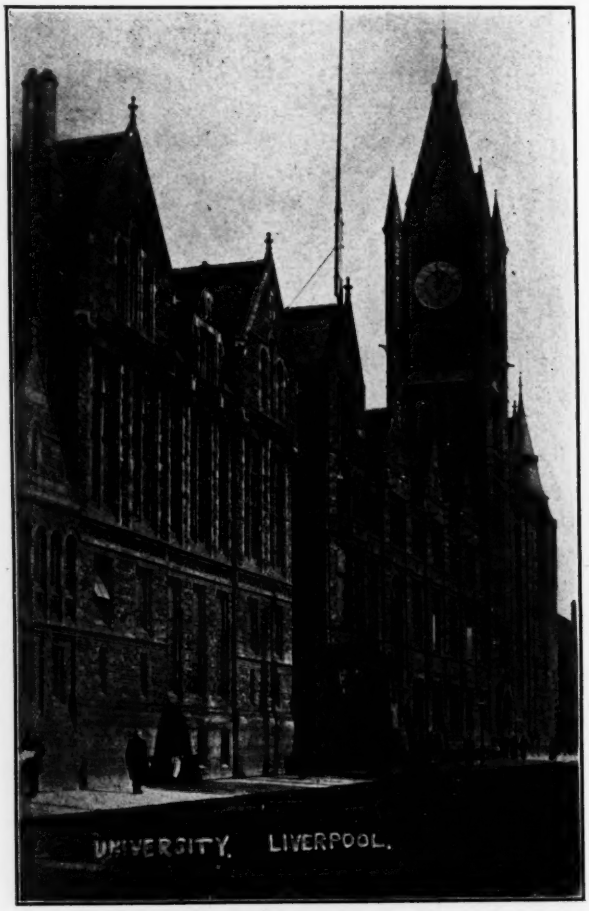
By EDWARD NELSON TOBEY, A.M., M.D.

NO plan for improving American medical education has been more widely advocated the past year than the establishment of a department of tropical medicine in our medical schools. Although we now have such possessions in the tropics as Porto Rico, the Canal Zone, the Philippines, the Hawaiian and other islands of the Pacific, not to mention our semi-tropical southern states, instruction in tropical diseases and conditions has not kept pace with the increased need. The founding of a school of tropical medicine in the United States was first suggested by the *Boston Medical and Surgical Journal* in the same year that two schools of tropical medicine were planned for England. Since England was the first to establish such a school, let us look toward that country.

Up from the Jewish quarter of the city, on the crest of Brownlow Hill, stands Liverpool University, famous, as some one has said, for its zoologist, its physiologist and its professor of tropical medicine. Entering beneath the tall Victoria Jubilee Tower with its clock and Latin inscription, and crossing the yard, one comes to the row of buildings containing the Thompson-Yates and Johnston laboratories, the former and present homes of the Liverpool School of Tropical Medicine. It was the work of this institution which caused a New York physician, when describing the advantages a medical student can get abroad, to write, "Liverpool leads in tropical medicine."

Although the school was founded a few months after the plans for its rival in London had been published, it was, nevertheless, the first to begin work. Its opening days were not darkened by any unfortunate incident, yet they were clouded by the lack of those favorable circumstances which have made the London school what it is to-day. The institution at Liverpool was not founded by the government, it had no grant nor assured income, nor even government recognition, hence it could not expect to get as many students as its rival. Some of these obstacles were removed later, yet they were important in determining the lines along which the school must work. A school which could not hope for much through excellence in teaching must look for recognition through research.

The necessity for conducting successful research was met by the appointment of Major Ronald Ross as professor of tropical medicine. The researches of Major Ross prior to his appointment at Liverpool



THE UNIVERSITY OF LIVERPOOL.

had disclosed the life history of the malarial parasite in the mosquito. That the mosquito was in some way connected with malaria was known as early as the fifth century, B.C., when Empedocles, a Greek philosopher of that period, delivered the people of Selinus, Sicily, from a pestilence by draining the neighboring marshes. Yet it was not until 1878, when Sir Patrick Manson observed the presence of the little worm, filaria, in a mosquito that there were any experiments to prove that mosquitoes carry disease.

In 1895, Major Ross, inspired by Manson, began to study the fate of the flagellating bodies which were first observed by the French army-surgeon, Laveran, at Constantine, Algeria. A few years later, being so situated as to be unable to continue his work on human malaria, Ross took up the same line of work in the malaria of birds. In July, 1898, he followed the development of the malarial organism

from the pigmented cells found in the stomach of the mosquito to the rod-shaped bodies in the salivary glands. He then exposed birds free from parasites to the bites of such infected mosquitoes, and fourteen days later these birds had parasites in their blood. In this manner were demonstrated the development of the malarial parasites in the mosquito, the mode by which they were transmitted and the fact that not every kind of mosquito will transmit the microscopic animal which causes the disease. Although it was in birds that the complete life-cycle of the organism was first followed, the pigmented cells which were a clue to the discovery were first seen in man.

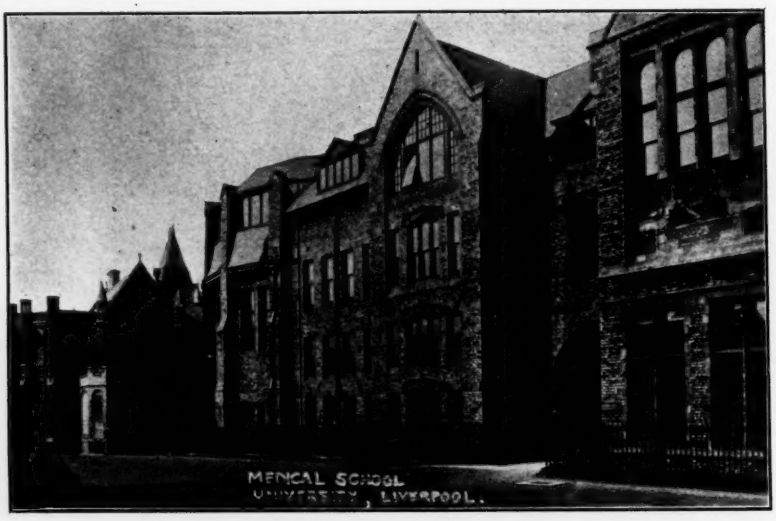
A few months after his appointment at Liverpool, Professor Ross left England for Sierra Leone, Africa, on the first of those expeditions which have made the school famous. The purpose of the expedition was to study still further the subject of malaria, but this time in the human being. Mr. Austen, of the British Museum, accompanied him for the purpose of collecting and studying the various kinds of mosquitoes and noxious insects.

This first malarial expedition was followed by many other such expeditions; and the value of the four measures for the prevention of malaria advocated by Professor Ross may be seen in the results that followed the expedition to Ismailia in 1902. Ismailia is a town of under 6,000 inhabitants, situated close to the Suez Canal and controlled by the Suez Canal Company. The number of cases there rose from 300 in 1877 to 2,250 in 1900. An active campaign of first detecting, isolating and treating the sick; second, segregating the healthy; third, mechanically protecting the well from mosquitoes; and fourth, reducing the number of mosquitoes by drainage or other treatment of their breeding places, begun in 1902, reduced the number of cases from 1548 to 37 in 1905; and all the old cases of 1905 were cases of relapse.

In 1902, Professor Ross received a Nobel prize for his researches on malaria. In 1906, he went on a malaria expedition to Lake Copais, Greece, and in 1907, he was sent at the request of the Government of Mauritius to give advice on the prevention of malaria in that island of the Indian Ocean. It will thus be seen that the work of Professor Ross is not only of scientific value, but thoroughly practical as well.

Another malady closely associated with malaria is blackwater fever. The classical description of this disease has been written by another teacher of this school, Dr. Stephens, who, next to Professor Ross, has done so much to spread a knowledge of malaria and tropical medicine. In 1907, Dr. Nierenstein, a chemist of the school, discovered certain etiological factors in this malady; and in July of the same year, the nineteenth expedition was sent to Africa to study blackwater fever.

A second disease conveyed by mosquitoes is yellow fever, which is distinctly American in origin. Found by Cortez in Mexico and un-



THE MEDICAL SCHOOL OF THE UNIVERSITY OF LIVERPOOL.

known in Europe until after the discovery of America, it has been epidemic many times in the United States, in places ranging from Pensacola to Boston. An excellent account of the last epidemic, which occurred in New Orleans, in 1905, has been written by Sir Rubert Boyce, the Dean of the Liverpool School.

Three expeditions have been sent from Liverpool to study yellow fever, and all the members of both expeditions to Brazil were stricken with the disease. Dr. Walter Meyer, a member of the first expedition, and a young man of great promise, died of the fever. One of the members of the second expedition had a severe attack of the disease, followed by disagreeable and disfiguring complications. His misfortunes did not end here; for, during convalescence, the river boat on which he was being carried sank and he barely escaped with his life, only to meet still further disasters in another land. Dr. Thomas, the other member of this expedition, has succeeded in conveying the disease to the chimpanzee by the bites of infected mosquitoes, thus affording a lower animal to take the place of the human sacrifices made to discover the cause, and also offering a hope for a cure.

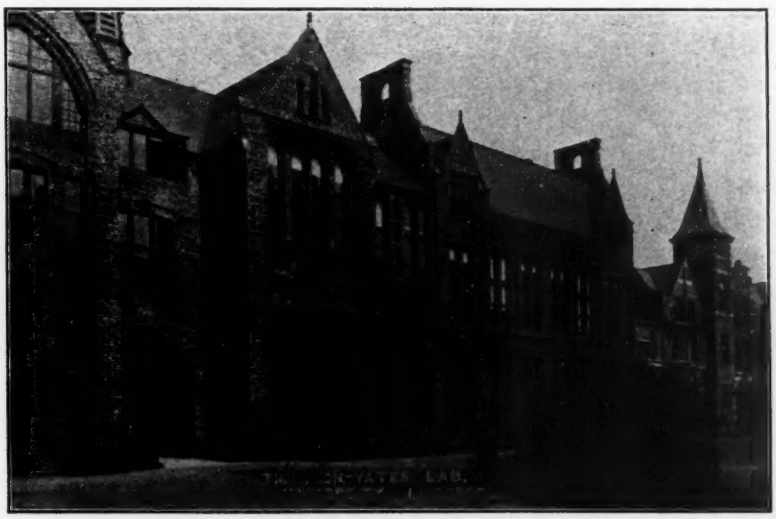
A third disease spread by mosquitoes is filariasis, a worm infection of the lymphatics and of the blood. The work of the school in this direction has been to describe a number of new species of filaria found in birds. This work is said to be in large part due to the observations of the late Dr. J. Everett Dutton, who so soon afterward made such important discoveries concerning two diseases of Central Africa.

The first of these African diseases, sleeping sickness, is spread by one of the biting tsetse flies. The cause of the infection, which had

escaped detection during a century of its existence known to Europeans, was at last seen by Dr. Forde, in 1901. It was Dutton, however, who first recognized that the little flagellate in the blood of Dr. Forde's patient was a trypanosome, similar to those which cause disease in lower animals. Dutton was the first to give full details regarding the character of the organism, to describe the symptoms produced by it and to give it the name it still holds.

The Liverpool school has sent four expeditions to study sleeping sickness. The experimental work which was carried on in England was begun in 1903 with material brought back from the Gambia by Dutton. At first the researches were conducted in Liverpool, but as the work expanded and the material increased, it became necessary to find a place in the country where the work could be more fittingly carried on. Such a place was found at Crofton Lodge and Cottages in Runcorn, a town sixteen miles from Liverpool. There, in a roomy rambling old country house beside a sunken road, with two tall holly trees guarding the entrance, might be found at one time research workers from India, Russia, Austria, Canada and the United States, who kept at their work from early morning until nearly midnight, and occasionally all night.

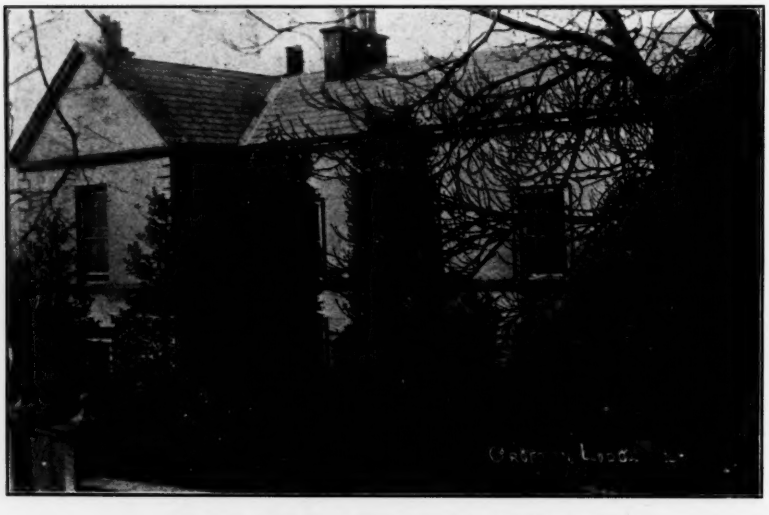
The most important experimental work of the laboratories in Liverpool and in Runcorn has been the search for a cure for sleeping sickness. These investigations were begun by Dr. Thomas, who was the first to use and recommend atoxyl, the remedy which Koch used later in Africa with so much temporary success. Although the little animal disappears from the blood and the fever subsides after the use



THOMPSON-YATES LABORATORIES, UNIVERSITY OF LIVERPOOL.

of atoxyl, there is later likely to be a recrudescence; and it was for this reason that two chemists at Liverpool, Professor Benjamin Moore and Dr. Nierenstein, conducted still further research for a better remedy. These men found that although atoxyl killed most of the organisms, a resistant form was able to withstand the action of the drug. A second remedy was then given during this resistant stage, and success seemed assured. The disease may continue for many years, however, so it is too early to know how effective the double remedy is in man.

It is interesting to observe that as in malaria the complete life-cycle of the parasite was first followed in bird malaria; so in sleeping



CROFTON LODGE, UNIVERSITY OF LIVERPOOL.

sickness what is apparently the complete cycle has been worked out in trypanosome infection of the frog. It was observed by Dutton in the Congo that the frog trypanosome undergoes another cycle of development outside the frog; and the recent experiments of Kleine in German East Africa seem to point to another cycle of development of the trypanosome of man in the tsetse fly. Thus the study of infections in lower animals may be of the greatest assistance in solving the problems of disease in man.

The other of these two diseases of Central Africa is tick fever. This infection was first described by Dr. Livingstone, the famous explorer, who found the disease in Portuguese South Africa, and attributed it to the bite of a tick. The discovery that spirochætes could be found in the blood of every patient ill with tick fever was first published by P. H. Ross and Milne, though there has been some doubt whether their work antedated that of Dutton. However, Dutton was

not only able to say that the cause of the fever was a spirochæte, but was able to prove by experiment that the spirochæte was conveyed to the healthy subject by the bite of a tick, the *Ornithodoros moubata,* and that the larvæ hatched from eggs laid by an infected tick, could convey the infection at their first feed.

Dutton's work in the Congo, on tick fever, was interrupted by the illness of both members of the expedition. This occurred at the time that Ross and Milne published the results of their discovery in Uganda. In February, 1905, three months later, Dutton died in Africa.

Further experiments were carried on in the laboratories at Runcorn, where it was found that the spirochæte of African tick fever was a new parasite, quite different from a similar organism which causes the relapsing fever of Europe. By common consent this new parasite was called *Spirochæta duttoni,* in honor of the hero who gave his life in an effort to relieve suffering humanity.

Such have been the results gained by the school in a study of five parasitic diseases conveyed by mosquitoes, flies and ticks. There are many other investigations of importance to the physician and scientist, but of less general interest. How valuable the work of the school may be in lines not strictly medical was recently demonstrated in the West Indies by Mr. Newstead, the entomologist of the twenty-first expedition.

This institution, great as it is, has been supported chiefly by annual subscriptions, as the school has no endowment. Foremost among those who have contributed most liberally is Sir Alfred Jones, who founded it. Another benefactor, who has shown his appreciation of the work done in the Congo, is the King of Belgium; and recently the English government has given its support. Much of the work has been planned and the interest in it aroused by the Dean, Sir Rubert Boyce.

This school, in the short space of ten years, has accomplished more than many an older institution.

THE GROWTH OF A LANGUAGE

By Dr. CHARLES W. SUPER

ATHENS, O.

WE now and then come across the statement that Shakespeare uses about fifteen thousand words and that he is the most copious writer in the English language in the matter of vocabulary. It is not difficult to count the number of words in an author after they have been registered in a concordance, but the statement as to Shakespeare's copiousness is misleading if not positively erroneous. It is safe to affirm that Sir Walter Scott employs more words since he has written upon a larger number of subjects. The same statement may also be made of Mr. Gladstone and of others. Besides, the mere number of different words used by an author is no test of his mental capacity, since the same word may have several different meanings and he have occasion to employ it in but one or two. "A bad case," for example, means one thing to a lawyer, another to a physician, still another to the moralist, while "case" unqualified has several more significations according to the context. It is easy to select one thousand words in any large dictionary that have five thousand different meanings. The radical sense of a word is a sort of stem from which all kinds of derivations shoot forth, or upon which they are grafted. Some of these, when used in certain cases or in a figurative sense, have only a remote relation to the original. "Case" in grammar is a good illustration. The Oxford dictionary, as far as completed, embraces, in round numbers 211,000 words. Of this number 130,000 are main words; 34,000 are subordinate words; 25,000 represent special combinations; 21,000 obvious combinations. About one fourth of the entire list is obsolete. Nearly two thousand years ago the poet Horace had noted the tendency of words to drop out of use and of others to come into favor.

> Yes, words long faded may again revive,
> And words may fade, now blooming and alive,
> If usage wills it so, to whom belongs
> The rule, the law, the government of tongues.

The vagaries of usage are past finding out. It is easy to see that when a thing passes out of use the name by which it was known is forgotten except by special students of the past. Readers of medieval history meet with many such. On the other hand, certain forms of words are discarded, current expressions become obsolete, while others are substituted because they embody a new thought and can not be dispensed

with. For the former no reason can be given. For example, "afeard" is a more logical form than "afraid" because of its evident connection with fear, but it is no longer considered fit company for refined society. The history of "astun," "astony," "stun," "astonish," affords another instructive example. "Climbed" and "heated" have taken the place of "clomb" and "het," although they are longer and more expressive. Generally speaking those words that are the most used are the most irregular. Our verb of existence —am, was, been—is made up of three different stems. Our grammatical auxiliaries are very defective; the missing parts have to be supplied in various ways. We say "I must" for the present, but we can not say "I musted" for the preterit, nor is there such a verb in English as "to must" although it is found in the Anglo-Saxon. "Might" is usually classed as the preterit of "may," but in many of its uses it is not. In all the languages of the Aryan stock, and in their descendants, we find the same lack of parts and the same alien substitutions. The changes that have taken place within the historic period are just as difficult, in fact just as impossible, to account for as the earlier ones. If languages were constructed according to any system, or even according to the most elementary principles of common sense, they would differ widely from their present status. It may be said in passing that some of the languages of the Turanian stock, notably the Turkish, are to a considerable extent symmetrically built. It used to be said that many words have been modified in obedience to the general law that tends to ease of utterance; but this explanation is no longer accepted. If such a law was ever operative an inexplicable break in the continuity of the human psyche must have taken place at some remote period in the past. Such a break would be at variance with the well-established course of development. It seems probable that human speech originated at three or more points on the surface of the earth. As long as these primitive tongues were left to develop according to their innate laws the process was consistent, if not logical. But when two or more of these original stocks came into conflict, each party trying in its clumsy way to acquire the speech of the other, confusion set in. If ten crassly illiterate Frenchmen and ten equally illiterate Hungarians were placed together where they would be compelled to communicate with each other we may be sure that in two or three generations a language would be produced differing widely from either parent. We have practical examples in the mixture of Norman French and Anglo-Saxon, of Iberian with Latin, and elsewhere, although these instances are not precisely such as I have supposed above.

As the Oxford dictionary is about four sevenths completed, the entire work will include more than 350,000 words. It is claimed by the publishers of the Standard Dictionary that the latest edition

contains 317,000 words. How many of these are obsolete or obsolescent can not be determined because it is impossible to draw a hard and fast line. Every successive work of this kind is larger than its predecessor, and the growth is very rapid. This is true not only of English, but of every living tongue, since all are in the process of accretion. And yet no English dictionary claims to include all the vocables that belong to the language, or at least are English. For the outlaws we have special vocabularies of localisms, dialect and vulgar terms, and so forth, which by themselves fill a number of large volumes.

We have an illuminating demonstration of the process by which word-lists grow in the case of certain compounds. In the eleventh English and the first American edition of Johnson the number of compounds with the prefix poly- is twenty-six; in the Century there are more than 550. Johnson gives no compounds with psycho-; the Century furnishes several columns. Lexicographers who aim at completeness can not exclude such compounds, yet many of them can not be classed as strictly a part of our language. With only a slight variation they may be found in the lexicons of every civilized tongue. They form a sort of international code. They are easily understood by every one who knows a little Greek and Latin, the former furnishing by far the largest contingent.

In this connection we are almost involuntarily led to ask the question, How many words does an ordinary man use? How many can he comprehend which he would not venture to use? How many words is the strongest memory capable of retaining? To the first question we have on record several answers. The late Max Müller in one of his lectures reports the testimony of an English clergyman to the effect that some of the agricultural laborers of his parish employed less than a thousand. A recent authority on the Gipsies declares that some of these people living in the villages of Sivas, in Asia Minor, although speaking a language that is clearly related to the Indic branch of the Aryan, do not have in their entire vocabulary more than six hundred words. Testimony of this kind should be received with distrust, although its falsity can not be proved. Some of the statements about the vocabulary of children before the age of five have been shown to be far too low. A person of fair natural ability, but of limited education, can comprehend a long list of vocables which he would not venture to use. There is no doubt that the popular audiences to whom Cicero addressed his Catilinarian orations followed him understandingly and with a fair degree of appreciation, although they were utter strangers to the beauty of his diction. Most persons understand preaching and popular lectures, even when the exact signification of many of the terms used by the speaker is not clear. The general run of the discourse has always a great deal of influence on the meaning of the separate words used by the speaker or writer.

Languages in which a written literature is not much developed, and a people among whom the art of writing is not much in vogue, take the factor of personal presence into account. Men who are familiar with the Turkish have noted a marked difference between its colloquial and its written form. It makes conversational sentences concise to the verge of obscurity, because in case of doubt the speaker can be asked to explain, whereas in writing it almost rejects the use of pronouns of the third person and employs a style like that of legal documents, full of repetitions of nouns coupled with "the said," "the afore mentioned," and so on. Discourses spoken, not read, to popular audiences are usually prolix. Every thought is elaborated; the same idea is presented in a number of different guises, as we may note in preaching, in political harangues, and especially in pleas before juries. How much the personal equation has to do with comprehension is easily realized if we read a drama, or even a monologue, and afterward hear the same from the lips of a competent actor or elocutionist. It is almost like a restoration of the dead to life. The ancient Greeks fully grasped the importance of the spoken word as compared with the dead letter of the written page. Homer's characters talk a great deal. Herodotus brings many of his men and women on the stage and lets them tell their own story. When Thucydides wishes to put before his readers the motives that inspire the different parties in their conflicts with each other he selects a representative of each, and brings him forward that he may present his side of the case in his own person. Plato traverses the whole domain of philosophy; but in order to relieve his doctrines as far as possible of their abstruse character he places before his readers a number of interlocutors in order to give them a lifelike setting. Few persons, when reading a novel, stop to think that the conversations so often reported to have taken place between two persons in strict privacy, or even soliloquies, are absurdly impossible.

The morphology and syntax of the Greek are so varied; their proper management requires such a high degree of grammatical and rhetorical skill; the precise meaning of a passage so often depends upon the nice choice and exact position of a particle; the tone of voice and stress with which it is uttered, that we can readily understand the aversion of those to whom it was native to the cold and lifeless word, even though we can not fully enter into the minutiæ of the causes which prompted the feeling. We have no means of knowing how many words with their definitions the human memory is capable of retaining.

There is, of course, a limit in practise; hardly in theory. The problem is closely related to that of the acquisition of foreign languages. There is not much difference between the ability to read several foreign languages and the ability to define the same number of words in one's own. Although the number of words in the largest English dictionaries

seems greatly to exceed that in the standard Greek and Latin lexicons, the difference is apparent rather than real. English dictionaries give every form in which a word may occur, slight variations only being excepted. The so-called irregular verbs fill only a few pages in the English grammars; yet they are usually recorded in the dictionaries. The irregularities of Greek and Latin verbs can, for the most part, not be found in the lexicons, and when recorded separately, make a large book. The latest edition of Stephanus's Greek lexicon fills nine volumes folio and more than ten thousand pages, while the definitive Latin lexicon now in course of publication will be as large as the Oxford dictionary.

Languages grow by incretion as well as by accretion. A new invention or a new discovery may be named by using current words. Thus "steamboat" and "railway" are compounds of obvious meaning because the sense of the constituent parts is already known and is not changed by the combination. It is true, "railway" is slightly misleading. The first tracks were made of wooden rails; when they were replaced with iron the earlier name was retained. In most of the continental languages the term "ironway" is in vogue, as railways were not introduced beyond the channel until wooden rails had been discarded, although the French still employs the monosyllable "rail" in its English sense. But not all words that have been compounded have an obvious signification; one or all of the parts entering into the combination sometimes lose their former meaning. To this class belong such terms as "stirrup-cup," "dog-watch," "monkey-wrench," "man-of-war," "horse-raddish," and many more. A dog-fight is a fight between or among dogs, just as a cock-fight is a duel between two cocks; in a bull-fight the combatants are bulls, horses and men. When the vocabularly of a language grows by accretion it is either by the incorporation of words borrowed from others that designate the same object or by the modification of a foreign word to designate some object previously unknown. To the first class belong paper, parchment, hippopotamus and a host of others. To the second, amœba, protoplasm, biogenesis, bacteria and a long list of technical terms. Horace has observed this process in his day, for he wrote

> New words will find acceptance, if they flow
> Forth from the Greek with just a twist or so.

It is by this method that science has constructed a language which has become, in a sense, international. One needs to know very little Italian, or French, or Spanish, in order to be able to read a scientific work intelligently. The translator of a well-known French medical book once told me that he had a mere smattering of the language, but as he was familiar with the subject he had no difficulty in comprehending the author's meaning. If this man had undertaken to translate selections from French literature or familiar conversation he would have

been swamped by the first sentence. When words pass from one language into another they are put through a transforming process before they can be naturalized. The republic of letters is, however, cosmopolitan and nationality counts for little; hence a term that is of interest only to savants needs to undergo but slight changes in order to be accepted everywhere. With popular words the case is different. An instructive example of this double genealogy is our familiar term "alms." It came into the English through the Anglo-Saxon from the Greek, in which language it has six syllables and is fairly well represented by our "eleemosynary," the form coined and introduced by scholars. The shorter word is the result of a gradual abridgment until but one syllable remains after it has been handed down by oral tradition through several centuries. If we trace this word in all its ramifications and transmutations in the languages of modern Europe we may see what strange freaks the laws of euphony play among the different nations. In Old Bulgarian it becomes *almuzhina,* in Polish *jalmuzhna,* in Hungarian *alamizna,* in Spanish *limosna,* in Portuguese *esmola,* in French *aumône.*

The ancient Greek philosophers must have given the phenomena of human speech a good deal of thought. As some of them came in contact with many tribes speaking different tongues, it would have been strange if they had not done so. As the problem presented itself to them it was whether language is a natural product of the human psyche, or the result of convention, a sort of social contract. Their speculations are, however, all lost and we have only the dialogue of Plato entitled "Cratylus" to give us an inkling of the discussions that had preceded the time of its composition.

Plato does not seem to have had a glimpse of the possibility that language might be an organic growth. He was unable to conceive that a work of such artistic excellence could be constructed by people so low in the scale of civilization that they had no conception of art. Too little was known in his day about the primitive instinct of men. Herein there is still much that is mysterious, if facts can be so designated. We know what is; how it came to be is veiled from our sight. As for Plato, there is no evidence in his writings that he knew any language but Greek. He shared the weakness common to his countrymen. In all Greek literature there are to be found comparatively few words that give the names of objects in other languages. From the era of Alexander's conquests until that of Constantine every intelligent person in the Roman empire spoke Greek; but not *vice versa.* Although Plutarch lived for some time in Rome and delivered lectures in that city, he knew Latin very imperfectly. Plato is willing to admit that words are subject to many changes and put on many disguises.

He acknowledges that the "poor creature" imitation is supplemented by another "poor creature" convention. But he does not see that "habit and repute" and their relation to other words are always exercising an influence over them. Words appear to be isolated, but they are really parts of an organism which is always being reproduced. They are refined by civilization, harmonized by poetry, emphasized by literature, technically applied in philosophy and art; they are used as symbols on the border-ground of human knowledge; they receive a fresh impress from individual genius, and come with new force and association to every lively-minded person. They are fixed by the simultaneous utterance of millions, and yet are always imperceptibly changing. They carry with them the faded recollection of their own past history; the use of a word in a striking and familiar passage gives a complexion to its use everywhere else, and the new use of an old and familiar phrase has also a peculiar power over us. But these and other subtilties of language escaped the observation of Plato. He was not aware that the languages of the world are organic structures and that every word in them is related to every other; nor does he conceive of language as the joint work of speaker and hearer, requiring in man a faculty not only of expressing his thoughts but of understanding those of others.

Language is one of the links that carry us back, if not to the origin of the human race, at least to the first articulate-speaking man. Words are the faded images, or the battered and bruised and worn coins, that have been handed down from the remotest ages. When they have received a form in literature they become in a measure fixed so that we can see how they looked to the eye, if we do not know precisely how they sounded to the ear, millenniums ago. We usually have a mere fragment of primitive words and are almost wholly in the dark as to their phonetic value.

The connection between thought and speech has long been recognized; sometimes the priority of the one, sometimes of the other has been maintained. One fact is indisputable: language greatly influences our modes of thinking; in our early years conditions it entirely. We learn to use words with the meaning attached to them by our environment. Our first ideas are exactly those of our parents, of older brothers and sisters, of schoolmates, and so on. When we begin to learn words from books our intellectual outlook gradually enlarges. The circle of our thoughts becomes wider, but only in rare cases does it extend beyond that of our generation. To the average man his mother-tongue is a current that carries him gently, imperceptibly and slowly along; he rarely stops to consider whither he is drifting. We pass on to our successors the inheritance of words into which we have come, generally unchanged and unaugmented. Only once in a while does the deeper insight of some thinker enlarge the boundary of our intellectual horizon. He may not use a single new term, at least none of his own coinage, but he puts into those he employs a sense different from what they had before. Such terms as "evolution" and "development," and such phrases as "survival of the fittest," have now a totally different

meaning from what they had half a century ago. And how pregnant with thought they are! While we have here no growth of vocabulary, we have an expansion of content that is of almost unbounded extent. We have a repetition of the same process which we find in the Greek when it began to be used as the language of philosophy. We may read page after page of Plato, knowing the radical or common meaning of his words; but if we are unfamiliar with Greek thought we get but a faint adumbration of his views. Our familiar "idea" is a good example of Plato's method with words. Its root is plainly a verb signifying "see." Herodotus says the horse can not endure the sight (idea) of the camel. In all Plato's writings it does not have reference to what is seen, but to what is mentally conceived, an archetype, or immaterial pattern of an object. In our day it is so common that everybody uses it. The colloquial forms "idee" and "idear" have grown out of it, and it may mean almost any form of intellectual activity. "Graft" is a recent and familiar example of a like process. Dictionaries ten years old do not give the definition with which we are all well acquainted. Some one made use of the word in its recent sense. Its appropriateness was at once recognized. It was copied by one periodical after another and repeated orally until now it is literally in everybody's mouth.

The usual assumption is that language represents a static fact; that it is to be found in books and in other printed and written matter; on tablets of stone and bronze. Language is, however, kinetic; all living languages are in a constant condition of flux. Through the mind of every human being from infancy until death, whether sane or insane, there flows a perennial stream of words that is interrupted only by sound sleep. When we read or listen to spoken discourse our thoughts usually run in an alien channel; but not necessarily. All languages are in a process of change which, although slow, is continuous. The English of Shakespeare or of Bacon is only a little more than three hundred years old, yet it is by no means the English of to-day. No matter how well we know current German, we can not read Luther's Bible intelligently. The same statement may be made of Rabelais's French, of Cervantes's Castilian and of Dante's Italian. It is a common error to speak of Greek and Latin as dead languages. The Romance tongues are nothing more than the latest phase of a development that has been going on since the earliest period of the Latin. If the Latin is dead now, when did the process of dissolution begin? The oldest French as preserved in the Strasburg oaths of A.D. 842 is about midway, as we may say, between the French of Hugo and the Latin of Cicero's age; a knowledge of either tongue enables one to read them with a fair degree of understanding.

The process of change is comparatively slow at present, and has been ever since the invention of printing, because readers endeavor to con-

form to the language of the past as preserved by the types. Albeit, we do not teach the language of Shakespeare or even of Addison, for the reason they have become archaic. What is taken as the best English of to-day contains a considerable number of expressions that are not found in Macaulay or DeQuincey, even when the matter dealt with is the same. We take as models English that is less than a century old. In some respects speech orally transmitted is more conservative than that which has been handed down in books; it represents a less advanced type of thought. The speech of the average man is not much influenced by books or by any printed matter. He repeats over and over again the formulas he learned in boyhood until language becomes his master rather than his servant. He does not reflect upon the speech he uses, but expresses the old familiar thoughts in the old familiar way; of other thoughts he has but few. At school he may have studied formal grammar, and wasted most of the time he put upon it. Grammar may give us an insight into the structure of a language, but it does not instruct us how to use it. If we take a boy into a shop, teach him the names of the tools and let him look on while others handle them without letting him do anything himself, he will never become a mechanic. Even if he has learned to manipulate the tools and machinery of a bygone era and refuses to change he is hopelessly handicapped. We can not discuss modern scientific themes with Bacon's vocabulary. There is an intersting passage in one of Herbert Spencer's essays that I have quoted more than once because it bears upon the matter of teaching the mother-tongue. Few men had a greater command of English and knew better how to make themselves understood than he. In "Facts and Comments" he gives his experience as follows:

> Down to the present hour I remain ignorant of those authoritative directions for writing English which the grammars contain. I can not repeat a single rule of syntax as given in the books, and were it not that the context has shown me the interpretation of the word when I have met it in reading, I should not know what syntax means. . . . In the absence of punishment my lessons in Latin grammar were never properly learned, and my progress was so slow that I did not master all the conjugations. Still smaller was the knowledge of the Greek which I acquired. In neither case did I reach that division which treats of the division of sentences. . . . Of the French grammar the same has to be said—I never reached the end of the conjugations. Thus neither directly nor indirectly have I received any of that discipline which is supposed to be an indispensable means of insuring correctness of speech.

This and much more to the same effect is interesting. But it would be a serious mistake to assume that the study of grammar is necessarily a waste of time. We might as well argue that because Franklin, Lincoln and others became masters of English without living teachers, schools are of no use. Spencer's remarks quoted above are followed by some logical and lucid directions as to the proper place of formal grammar in the ordinary school curriculum. If we learn to do by doing, we learn

to speak and to write by writing correctly. It was in this way that the masters of Greek and Latin literature acquired their skill. They heard these languages correctly spoken; they saw them correctly written; they were taught rhetoric, but not grammar. Later the rules of the art were deduced from the study of connected discourse, among others of Homer. Here is a matter that defies analysis or explanation. We can only say that the masters of speech knew by a sort of instinct how to give their inflected words one form when occupying a certain place in the sentence and another when occupying another. Every word in the Homeric poems can be "parsed," that is, its position in the sentence can be logically and historically explained; yet they are the production of hundreds of men of whom probably not one could write. In its earliest stages language was correctly used by instinct; we later-comers are compelled to do so by a laborious process because we do not hear it correctly used. Instruction in the native tongue is a comparatively recent innovation. Why should an Englishman be taught English when he learned it in childhood? He was put to the study of Latin, and perhaps of Greek; English was left out of the account.

Bacon says:

> **Words are formed at the will of the generality, and there arises from a bad and unapt formation of words a wonderful obstruction to the mind. Nor can the definitions and explanations with which learned men are wont to guard and protect themselves in some instances afford a complete remedy—words still manifestly force the understanding, throw everything into confusion and lead mankind into vain and innumerable controversies and fallacies.**

That is, as speech always represents the past, those who use it are unconsciously influenced by the thoughts of those who employed it in former times. There is thus an inherent weakness in adhering to what is commonly called a classic style, the style after which the literary man strives. On the other hand, the scientist is always on the lookout for something new; he must use new terms, if not new forms of expression. While a scientist may set forth general principles in a model style, when he becomes technical and precise this is no longer possible. Thus there is a certain degree of incompatibility between the scientist and the litterateur.

In the consideration of human speech we must take into account two factors: one subjective, the other objective. They are as nut and screw, as lock and key, as hand and glove. These two factors must grow up together, so to speak; they must at least become thoroughly familiar through long association. Viewed in respect to language, the human mind may be compared to a hard substance upon which it is difficult to produce impressions, upon which impressions can be made only by oft-repeated blows. But *impressions* is merely a make shift word borrowed from the material world for lack of a better. The passive mind does not comprehend the meaning of a word or phrase

until its form or sound and signification have been thrust upon it over and over again. How many thousand times are familiar expressions repeated in the hearing of the infant before it understands what they mean, at least with any degree of definiteness. The adult foreigner is almost in the same predicament. After a familiarity between sound or character and idea has been established comprehension proceeds with amazing rapidity. We can run our eyes over a printed page and get its meaning much more quickly than we can pronounce the words. Like a skillful pianist who reads an unfamiliar piece of music at sight, since only the particular combinations of notes are new to him, but not the general principles upon which the score is constructed, so the reader of the printed or written page is familiar with the words before him even when their arrangement and combination are new. Words and phrases may repose passive in the subconscious mind for many years, dead and forgotten as it seemed, when suddenly either by conscious effort or by an accident of association they spring into life. It is doubtful whether we can ever forget a language learned in childhood, although lack of practise may make us awkward in its use in after time. Sometimes we may grope, so to say, for years in the effort to recall a word, especially a proper name, when something suggests it to us at an unexpected moment. It is like the powder which lies dead as so much dust until a spark falls upon it, when it bursts into flame. The latent image, figuratively speaking again, can usually be called into life more quickly if the eye and the ear cooperate, than when only one of these two organs is called into requisition. It is, however, easier to learn a language through the eye than the ear; in fact, many languages can be learned only in this way, since they have been preserved solely upon inscribed materials. If a word is unfamiliar at first sight we can keep the eye upon it until it is either recognized or until we have convinced ourselves that recognition is impossible. A dead language is, however, a good deal like a cadaver; the important thing, life, is wanting.

A visible fact connected with the internal growth of a language is its geographical expansion. The ancient Greek furnishes a remarkable example. Four or five centuries before the Christian era it had already spread over the greater part of the known ancient world. By the conquests of Alexander it was still farther extended. In the course of time it was in some degree superseded by the Latin, at least in Europe. Albeit, Latin never became the popular speech that Greek had been, although it was the medium of communication between ecclesiastics and scholars and so continued until displaced by the modern languages of which French had for a time the precedence. The lectures in the universities were given in Latin; hence we find the same distinguished scholars teaching in succession in half a dozen different countries and their books circulating even more widely. The tradition was first abro-

gated in England and was longest adhered to in Germany, in which country university lectures were delivered in Latin by a few professors within the memory of the present generation. To some extent French was for a long time the most generally spoken language. Professor Fouillée, in his "Psychology of the French People," asserts that toward the end of the seventeenth century France had twenty millions of inhabitants; Great Britain and Ireland, about nine millions; Germany, nineteen millions; Austria, somewhat less than thirteen millions, and that among the fifty million inhabitants of Europe France comprised about forty per cent.[1] Besides, if a person spoke two languages, one of them was almost invariably French. In 1789, according to the same authority, France had a population of twenty-six millions; Great Britain and Ireland, of twelve millions; Russia, of twenty-five millions; Germany, of twenty-eight millions, and Austria, of about eighteen millions. France now represented only twenty-seven per cent. of the inhabitants of Europe, Russia having meanwhile taken its place among the great powers. France continued to decline until the close of the nineteenth century, when it included only about eleven per cent. of the population of Europe. Nobody knows how many persons speak Russian in the proper sense of the word, but probably a good deal fewer than one half of the citizens of the empire.

Let us now glance at the career of the Castilian tongue. At the death of Philip the Second the population of Spain is estimated to have been about eight and a half millions. Towards the close of the seventeenth century it is supposed to have sunk to about six millions, since many villages were deserted and long stretches of country lay uncultivated. Within the next eight or ten decades there was considerable improvement, so that by the beginning of the nineteenth century the population is believed to have doubled. The number of inhabitants in the Spanish American states is estimated at about thirty-six millions. Outside of these countries, and including Cuba but excluding the mother-country, there may be one or two millions of Spanish-speaking people; this makes the entire number between thirty-eight and forty millions. But so badly managed are the internal affairs of the Central American states that the best possible "guess" at the number of their inhabitants may be wide of the mark. Of this total population not one tenth, more likely not one twentieth, has received systematic instruction in any language or in anything else. Besides, the number of persons of pure Spanish descent outside of the mother-country is comparatively small. As it is reputed to be but nineteen per cent. in Mexico, the total number of Spaniards at the present day may fall far short of the above estimate: that is to say, if we credit Spain with eighteen millions

[1] Page 321. It will be noticed that if the figures are correct the per cent. can not be.

and the rest of the world with nine millions we get a total of twenty-seven millions, which is probably a liberal allowance. We are, however, here concerned with the language of the Spanish-speaking people, not with their ethnology.

Coming now to England, it is calculated on the basis of the parish registers, as no one in those days thought of taking a census, that its population, including that of Wales, at the middle of the sixteenth century was about five millions. Two centuries later it had risen to six and a half millions. At the present time the number of persons whose native speech is English, or one of them if they speak two, falls not far short of one hundred and fifty millions. There are many persons in Wales, in Canada, and in other parts of the world who use two languages with about equal facility, but who would not claim English as their mother-tongue. Probably as many as three fourths of this number have received, or are receiving, systematic instruction in the English language. It is probable that an equal, if not a larger, proportion are of Anglo-Saxon, or at least of Germanic stock.

I have spoken above of the aversion of the ancient Greeks to the acquisition of foreign languages. In modern times the French have manifested a similar reluctance. As "France marches at the head of civilization," why should Frenchmen concern themselves about those who are behind them? When almost every intelligent person in continental Europe knew French a Frenchman rarely took the trouble to learn a language spoken outside of his native country. This ignorance eventually cost the nation dear; for if Frenchmen had kept themselves informed of what was going on beyond the Rhine they would have been less eager to engage in a war with the nation that dwelt there. The same charge is frequently brought against English and American representatives of commercial houses in foreign countries. We have been told many times that the United States lose a great deal of trade because their agents will not take the trouble to learn the language of the natives with whom they desire to do business and that the Germans far outstrip them in this respect. It may be said further that the efforts of the Germans to preserve their speech in foreign countries meets with small success. The children of German immigrants rarely learn the language of their parents so well that they are able to use it as readily as that of their new habitat.

We have here what seems to be the only practical solution of the problem of a universal language. When we take note of the rapid expansion of English within the last century, it does not seem a fanciful prediction that before the end of another century all persons who wish to learn another language besides their own will choose English. German received a serious set-back by the Thirty Years war. The population of the country in 1618 is estimated at twenty-five millions. There are

good reasons for believing that it had been reduced to half this number by 1648. It is therefore not putting the case too strong to say that it required almost two centuries for Germany to recuperate from the effects of that terrible scourge. It is the most impressive lesson the world has received on the folly of war; but for this one, the history of the world would probably have been widely different. There is a sense in which a detriment of this kind can never be made good. Spain's linguistic losses at home may be ultimately restored and more than restored by conquests in her colonies. Conversely, Germany has thus far not been successful with her over-sea possessions, partly owing to bad management, partly owing to climatic and other unfavorable conditions.

English is the coming language. And it is coming rapidly; for while it is difficult to learn thoroughly, in the matter both of style and of pronunciation, it can readily be acquired with sufficient correctness for all commercial and practical purposes.

THE DENOMINATIONAL COLLEGE

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THAT church and state should be separate has long been held in the United States. It is one of our proudest boasts that every citizen of our country is free to worship God in his own way. It is also usually assumed that each may have his own definition of the God he worships. Our educational system, as well as our government, is based upon this assumption that it is best for state and church to be entirely independent of each other; for, in America, as in most enlightened countries, the education of the youth is considered a duty of the state. The public schools provided for by public funds are non-sectarian. The highest branches of the system, the state college and state university, are similarly constituted and similarly provided for. Neither upon entrance in these institutions nor later is any profession for or against any religious denomination, or any expression of "attitude," demanded of boards, trustees, presidents, principals, instructors or students. Religious organizations are permitted to exist among the members of these institutions, and are accorded the same assistance and courtesies as are technical, literary or purely social clubs, but the fact that they are religious organizations does not of itself entitle them to any additional consideration.

This is apparently an ideal condition. Our educational system attends to the intellectual and technical training of our youth, and to the task of developing them into useful and desirable citizens. The church, an independent organization, gives such religious and theological instruction as each citizen desires for himself and his family. Each citizen follows his individual preference as to the kind of religious teaching he needs, and of his own free will pays for it, directly instead of indirectly, and in accordance with his own rating of his duty towards it and the value of the services which it renders.

Unfortunately, however, this apparently ideal condition exists in but a part of the educational machinery of the United States. Besides our excellent system of public grade schools, high schools, technological schools, colleges and universities, we have an enormous number of educational institutions which were not founded by public legislation, and are supported by private munificence. The entire situation may be stated as follows: (1) Our city evening schools, schools for the blind, reform schools, Alaskan and Indian schools, are entirely public institu-

tions; (2) the miscellaneous schools (of cookery, music, oratory and various special arts), the business schools, the orphan asylums and other benevolent institutions are founded and supported as private institutions. Of the remaining educational institutions, some are public, some private. The percentage of attendance of pupils and students, as calculated from the table given on page viii of Vol. I. of the Report of the U. S. Commissioner of Education printed in 1907 (from which are taken also the general data given above, and which will hereafter be referred to simply as U. S. Report), is as follows:

Kind of Institution	Percentage in Public Institutions	Percentage in Private Institutions
Schools for the deaf	95 +	4 +
Schools for the feeble-minded	95 +	4 +
Elementary schools (primary and grammar)	92 +	7 +
Normal schools	83 +	16 +
Secondary schools (high schools and academies)	79 +	10 +
Colleges and universities	33 +	66 +
Professional schools	17 +	82 +

It will be seen that the state is doing in a tolerably complete manner what it has evidently assumed is its duty, in all but two of the classes of institutions to which it gives any attention whatever. But in the case of the professional schools and the colleges and universities the state is merely dabbling in the matter, leaving so great a proportion of the work to private enterprise that of the youth being educated in such institutions seventy-four per cent. are receiving such education through private munificence. If our postal system, or our system of criminal reformation and punishment, were carried on partly by the state, partly by private enterprise, we should regard it as a very curious condition of things, and should cast about us for a remedy. But as yet we fail to observe the anomaly in this very important matter of public education.

Let us now take up the subject from the point of the comparative number of public and private institutions, rather than from that of the total attendance of students, and confine our examination to one of the two kinds of institutions of which the state controls but an insignificant proportion. We may classify the colleges and universities conveniently through the aid of tables 29, p. 578; 32, p. 636 and 34, p. 640 of the U. S. Report. All institutions classed as schools of technology (table 36, p. 650) are omitted from this consideration, even though their official title is sometimes "College of ———." (It may be stated in passing that according to this table the national government is responsible for 2 and the states for 34 of these institutions. The source of support or the founder of the remaining 8 is not specified and has not been investigated.) These statistics may be

regarded as tolerably correct, although inaccuracies undoubtedly occur. Consequently the general view of the situation which they offer is approximately correct.

Many of the universities of the east have at one time or another received appropriations from the state, and some state control has been and still is exercised. But such institutions must nevertheless be classed as private rather than public. The comparative number of colleges and universities under public *versus* private control is as follows: National, 2; state, 46; city, 4; private, 620. The total is then 52 founded and chiefly if not entirely supported by public funds, as against 620 privately founded and privately supported institutions. Some of these private colleges and universities date from the early days of American history, when the government was not yet strong enough to undertake educational work, and private organizations gave their time, energy, and money to its accomplishment. The fact that the government is now able to do its duty along the line of education of its citizens does not in the least detract from the high honor due those early pioneers who by individual effort paved the way for the accomplishment by the state of a great and necessary task.

These six hundred and twenty privately founded institutions, which still educate almost twice as many of our young men and women as do the public colleges and universities (*Cf.* tables 1 and 2, pp. 545 and 546 of the U. S. Report), are as a rule conducted in accordance with the personal wishes of their founders and, according to the three tables quoted above four hundred and seventeen of them are avowedly denominational in attitude. The term denominational is here used in its broadest sense, to include both Roman catholic and protestant institutions. These colleges and universities are, of course (though why "of course" is as yet unexplained), all exempt from taxation. This one fact proves beyond cavil that church and state are not separate in America. Exemption from taxation of an institution of learning which also gives religious instruction or brings religious influence to bear means to this extent state aid, and consequently direct connection with the state.

The citizens who at its foundation endow a denominational institution and continue to support it also pay their share of the tax which supports the state college and state university. It seems at first, then, that their right to maintain in addition their own private institution for religious teaching should pass unchallenged, and, if the denominational college were for religious teaching alone, none might object. But its religious teaching is greatly adulterated. The denominational college and university compete with the work of the state institutions, and infringe upon the right and duty of the state to attend to the intellectual training and preparation for citizenship of its youth. The specious argument may be presented that these private institutions,

founded in the past to accomplish the twofold task of educating ministers for the ministry and citizens for citizenship, still exist for the sake of helping out with the educational work of the country, the great task of the state colleges and universities. But the state will not do its whole duty until the entire responsibility devolves upon the state alone. If the state does not provide enough colleges (using this general term now for both college and university), it is the state and no one else who should set about the task of providing additional ones. The state is no pauper on the hands of its citizens when it comes to a question of providing and maintaining a sufficient number of reform schools or of penitentiaries. No more should it be so in the far more vital matter of the education of its normal and desirable citizens.

Briefly, the national, state and municipal governments are not doing their duty until their citizens are offered such adequate opportunity for intellectual and technical training as to render unnecessary all such offering of opportunity by institutions founded upon a private or religious basis. This position places no difficulty in the way of private citizens or organizations who wish to give direct financial aid to institutions of learning. Their gifts would instead reflect higher honor upon them, inasmuch as they would be a manifestation of unadulterated patriotism. Those who wish to give to the cause of religious instruction would find the field as large and attractive, and untrammeled by other real or apparent motives, in the various institutions or organizations to which their donations would be made.

Moreover, the impetus in this matter must come from the state itself. The remedy will not be begun by the denominational college, for, unless something is done from without, it will continue to exist from mere inertia. The remedy will not be begun by the students, for they will in general follow the line of least resistance, and attend the institution which other members of their families and their friends have attended. They will attend the college which their parents aid materially with financial support. They feel a moral obligation to help swell its roll of attendance, and they have been taught, as were their parents before them, that the college supported by their church deserves somehow a more direct and solicitous care and interest and aid than does the college supported by their state. Yet it is the students of the denominational college who receive from it the most direct harm, along with the educational advantages of which they avail themselves. They are subjected daily to the influence of some particular denomination, in either a direct or indirect method. The denomination may be the one to which their parents belong, and to which they would also ally themselves, or have already allied themselves; but the harm consists in that they are led blindly along, instead of being left to make the choice of their own free wills, as our country in the beginning proposed

every one should be. The harm consists even more in that all through their course of study they find general and religious education constantly commingled, in direct contradiction to the assumption that religious freedom exists in America. The student has no way out of the dilemma but to assume that the freedom is simply a freedom as to which particular denomination shall for him be united with the state. The list of denominations from which he may choose is a limited one, inasmuch as of the seventeen denominations represented among the four hundred and seventeen avowedly sectarian colleges, almost three fourths of them are under the control of but four denominations, as will be shown from the following table, deduced from tables 29 and 32 of the U. S. Report.

Methodist. 104 (24— Per Cent.)	Presbyterian. 75 (18— Per Cent.)	Baptist. 68 (16+ Per Cent.)	Roman Catholic. 65 (15+ Per Cent.)	Lutheran. 26 (6+ Per Cent.)	Christian. 17 (4+ Per Cent.)	Congregational. 16 (3+ Per Cent.)	Reformed. 9 (2+ Per Cent.)	Friends. 8 (2— Per Cent.)	United Brethren. 7 (1+ Per Cent.)
Universalist. 4 (⅞ Per Cent.)	Evangelical. 4 (⅞ Per Cent.)	Moravian. 3 (⅝ Per Cent.)	Latter Day Saints. 2 (½ Per Cent.)			Seventh Day Adventists. 1 (¼ Per Cent.)			Church of God. 1 (¼ Per Cent.)

Episcopal. 7 (1+ Per Cent.)

The stigma of "godless institution" used as an epithet of reproach, is so often applied to the college of the state by zealous supporters of the private college as to actually give the student the impression that an institution which does not combine some form of religious teaching or influence, some Sunday school work, with its general instruction, is acting in opposition to the good of the country, rather than in conformity with one of its most cherished principles.

It may be that the student does not wish to ally himself with any of the religious denominations which maintain colleges, but attends one of these colleges since there is no restriction announced as to the church membership or religious affiliation of prospective students, but instead a distinct effort made to win any and all students of general good character. He will be subjected constantly to petty humiliations because he does not worship his God in the same formulas as do his fellow students. If he fail to attend even the "voluntary" chapel and Sunday services conducted by the college, not to mention the various prayer services, he realizes that his absence is noted by classmates and members of the faculty, even in the unlikely case that no comments are made. In order to escape isolation and a greater or less degree of

ostracism, he finds it expedient to attend the services. He goes through with song, prayer, responsive reading, or whatever form the exercises may take, carefully concealing his lack of sympathy with them. In this way a definite species of hypocrite is developed. Our colleges, to their unspeakable shame, are full of such products. They occur among instructors as well as students, for the instructors must add to the reasons of the student the additional one that they wish to retain their positions. Consequently such instructors attend and even assist in conducting services with which they do not feel the least genuine sympathy. The fault is not that of instructors and students, for they came for educational purposes to an institution which avows that its aim is educational, and that no distinctions are made on account of religious attitude. The fault is that of the college, in bringing to bear a compulsion of such a sort that there is no resort but submission and consequent hypocrisy.

Granting, therefore, that the denominational college is a pernicious and undesirable incubus upon the American system of public instruction, it becomes advisable to define the term more exactly, and to make it more clear that in it are combined church and state inasmuch as religious education and general education are here given in combination, in an institution exempted by law from taxation. The denominational college may then be defined as follows: A general educational institution which (1) was not founded by and is not supported by the state (state in this sense including national, state and municipal governments), which (2) aims to further the cause of some one religion or of some one religious denomination, which (3) holds daily religious services during each college week, which (4) makes some limitation in regard to the church membership of its trustees, president, or teaching force.

The examples given in this article will be from protestant rather than from catholic or jewish colleges, simply because the writer is best acquainted with the protestant colleges. The statistics given are based upon those of the United States commissioner of education, who makes his report chiefly concerning protestant and catholic colleges. The conclusions drawn, however, should be the same for all religions and religious denominations.

Beginning with a consideration of the second clause in our definition, we may see the method in which this is accomplished, from the following quotations. In the original articles of incorporation of a highly reputable college we read as follows:

> **The object of this institution shall be to promote the general interests of education and to qualify young men for the different professions and for the honorable discharge of the various duties of life.**

In the historical statement of the catalogue of the same college we find:

The college has not lost sight of the design of its founders that it should be a thoroughly Christian institution.

In a supplementary catalogue of the same college we learn that the instructing force

may assemble the students as freely for song and prayer as for athletic associations and class parties. There are no restrictions at this point, either directly or indirectly. The atmosphere is just as religious as the teachers and students choose to make it.

The reader will note that the "freedom" here referred to lies wholly in the teachers' privilege of increasing the already existing religious atmosphere, not in any possibility of curtailing it.

Each of the three following quotations is from a catalogue of a college of excellent standing. The first reads:

In accordance with the spirit of the founder, the college is undenominational, but distinctly Christian in its influence, discipline and instruction.

The second is similarly worded, as follows:

All instruction is given from the religious viewpoint with reverent recognition of and regard for the divine wisdom and power hedging us about and with which we have to do.

These statements do not leave us to infer that religious instruction is simply coordinate with other instruction, but make the claim that the teaching is a combination of the two. A *reductio ad absurdum* would lead to the query how Christian or religious mathematics differs from secular mathematics, or how such an interpretation of Horace's "Odes" or of the "Chanson de Roland" differs from the secular interpretation, and whether Christian bacteriology differs from catholic or jewish bacteriology. A more moderate statement in this regard is exhibited in the third citation:

It is a Christian college, conducted in the belief that Christian faith is the source of the highest culture, and that, in the words of its founder, "All education should be for the glory of God"; and accordingly it uses the means which legitimately come within its province to foster a Christian life in those who are connected with it.

A rather naïve method of cooperation of college and church is shown in the following citation, again from a catalogue of a college of high standing:

The college is distinctly Christian, and recognizes Christian character as its highest attainment. It is unsectarian in its management. Inquiry is made of the students at entrance as to their denominational affiliation, and what churches in the city they desire to attend. Lists are sent to the pastors of these churches, who seek out the students and bring about them the influence of church homes.

Apparently this inquiry and resultant action is official on the part of the college. One is tempted to wonder what disposition is made of students who signify a desire to attend a church of some denomination not represented in the city in which this college is situated. Possibly

a substitute is offered, with the assurance that it is "just as good." In case a student does not wish to decide upon his church affiliation until a later date than that of his entrance into college, special action is perhaps taken upon the case. Further quotation of such examples is forbidden by lack of space. Any one who will take the trouble to examine a dozen non-state college catalogues, selected quite at random, will realize that there is no scarcity of examples fully as pertinent and often even more striking than the ones cited above.

In passing to the third clause of the definition, we realize that definite and individual examples are hardly necessary. It is the exception, not the rule, if any non-state college does not hold its morning chapel, its Sunday service, and its Sunday vespers. It is usual, as will be seen from an examination of catalogues, for these services to be compulsory. Attendance is "required," with or without penalty for non-attendance, or is "expected," or "urged" or is "voluntary," which latter word may be variously interpreted. For the sake of definiteness, however, some citations may be made from catalogues:

> The principles and influences of the college are distinctively Christian, but the college has no connection with any particular denomination. A short service is held each morning in the chapel at a quarter past nine o'clock. All students are required to be present at this service, and on Sunday are expected to attend the services at the church of their choice. . . . On Sunday, vesper services are held in —.

Another example is as follows:

> Every undergraduate student is required to be present twice each week at morning prayers in the chapel, unless excused by the president. If a student at any time falls short of this requirement by four absences he must during the next two weeks attend four times in addition to the four times above provided for. Failure to comply with this rule will render him liable to suspension. Every undergraduate in residence at the university is required to attend at least one half of the Sunday chapel services each quarter. Failure to comply with this rule will render him liable to suspension.

Still another citation, from the catalogue of still a third college, is as follows:

> Daily attendance at morning prayer or an alternative duty, as described below, is required of every student, except seniors enrolled in a university professional school down town. These chapel exercises are held from 10:15 to 10:30 each morning. For every fifteen absences, a student will be required to hand in within ten days after the fifteenth absence an original theme of 800 to 1,000 words upon a subject assigned him by the chancellor touching morals and religion. This theme will be graded according to its merits, and awarded the same weight in determining the student's standing as if it were a course requiring fifteen hours' recitation. Two failures to hand in themes will be entered as a condition, being treated as a failure in a term examination. Where a student is absent from college for five or more days continuously, with a good excuse, his chapel absences will be excused also. Where a student is absent from college less than five days continuously, even though excused, his absences from chapel will be counted.

In many colleges attendance at daily chapel is not compulsory, and no penalty is imposed for non-attendance. In such institutions there often exists a "custom" which has almost the same effect as the written rule. The libraries and reading-rooms are closed during the chapel hour, and instructors are officially requested to lock their class-rooms, so that no place for work or recreation is left to the students during the session of chapel. Students who in spite of this arrangement fail to appear with due regularity at chapel are made the subject of unpleasant comment among their fellow students and often directly, while instructors who do not feel the impulse toward worship at precisely the same hour of the day as their colleagues receive from the president or some other official a gentle reminder that their presence at this "voluntary" chapel is advisable.

The last clause in our definition is an important one. The reader will doubtless think at once of one of the greatest and best universities of our country, the president of which must always be of a certain religious denomination. His personal preference as to Tennyson or Browning is not inquired about, nor is he asked whether he believes in high tariff or free trade, or is a prohibitionist or a socialist. But investigation is made as to whether he has formally subscribed to a certain creed of a certain religion, although no one thinks for a moment that he will make a better executive on this account, or even did think so when the ruling was made. That all or a certain number of the trustees of a college shall be members of a specified church is likewise a familiar state of things, hardly needing illustration. For instance in the historical sketch of a certain college founded by a private citizen, it is mentioned that this gentleman was of a certain religious denomination "and he provided that the trustees of the institution should be members of that body." In the catalogue of another college we find this statement concerning its charter: "It provides that the number of trustees shall never be greater than seventeen, seven of whom shall be clergymen and ten laymen."

No one who has given the matter slight attention would be inclined to believe that the point in our definition concerning church membership of the instructional force applies to but an inconsiderable number of institutions, and is the exception rather than the rule. The contrary, however, is the case. Proof from a different source than the college catalogue is at hand, and has the advantage of being absolutely disinterested in its origin. Such proof consists in the blanks of teachers' agencies. These blanks almost invariably, and probably always, contain the items "church membership" and "church affiliation" in the list of "qualifications for teaching" to be filled out by the prospective teachers. This information would not be asked for were it unnecessary. Moreover, the writer has the opportunity of quoting from letters written in a most kindly attitude by teachers' agencies of high standing, con-

cerning registration blanks in which membership in orthodox churches had not been indicated. The first extract is as follows:

> It will not help you . . . that you are a member of the Universalist church. . . . Sometimes employers will go so far as to state that they want a member of the Methodist, Congregationalist, Presbyterian, or Baptist church, these four being the most common of the so-called orthodox churches.

It is of interest to note in passing that this agency discovered by business experience what we have above shown by statistics, as to what denominations control most of the colleges. In our statistics, Methodists, Presbyterians and Baptists lead, Roman Catholic, which evidently does not employ the aid of agencies, or of this particular agency, to any noticeable degree, being fourth. In our statistics Lutheran and Christian come next, followed by Congregational. The reason that Congregational seems to this agency to rank with the three first quoted will doubtless appear from the latter part of this article. Another extract from a similar letter is as follows:

> It is likely, however, that you will be handicapped there, as you will be handicapped in most colleges, by your lack of church membership. Have you never been a member of a church? You understand that most colleges are directly or indirectly connected with some church, and as a general rule the president insists upon membership in some church.

An extract from a third letter reads as follows:

> You are handicapped for the majority of positions for which you would otherwise be eligible because you are not a member of a church. We had a letter to-day from . . . that is in no way sectarian and yet they absolutely demand in the teacher they desire a member of some protestant church. Frequently the denominational schools make no requirement as to a particular church but do demand membership in some church.

Let us now return to a statistical consideration of the private educational institutions. We have noted that of the 620 such colleges, listed in the U. S. Commissioner's Report, tables 29, 32 and 34, 417 are avowedly denominational. Of the remaining 203, 99 are quoted as non-sectarian, while four are not specified. In the catalogues of three of these four, the claim is made that they are non-sectarian, thus bringing the number of such colleges up to 102. From the definition of denominational or non-sectarian college which we have accepted, it follows that any college which conforms to all or even half of the four clauses of this definition may not be called non-sectarian. Stating this affirmatively, we find that: Any college which (1) was founded by a private citizen or organization of citizens, and which (2) conducts devotional exercises at least five days in the week at which student attendance is "required," or "expected" or "urged" or not distinctly stated as "voluntary" in its catalogue, may not rank as non-sectarian, in spite of any claims it may make to that effect, but must rank as a denominational college. In case a college was privately founded, but

states in its catalogue that all religious exercises which it conducts are "voluntary," such college shall not be classed as sectarian unless some stated restriction exists concerning the church affiliation of its president, or all or a part of its board of trustees.

Of the 203 colleges to be considered with reference to the above definition, the catalogues of 62 have been examined. No investigation has been made of the colleges of secondary rank listed in table 34 of the U. S. Rep. as "Colleges for women, Division B," of which 32 claim to be non-sectarian and one is not specified. The conclusions to be drawn for these 33 would doubtless be similar to those which we shall deduce from the remaining 70 colleges which claim to be non-sectarian. An examination of the catalogues of 63 of these 70 colleges gives the following results: In accordance with our definition, 16 of these institutions may fairly rank as non-denominational colleges. The remaining 47 out of 63, that is to say, 75 per cent., of the colleges examined, must be classed as denominational. It may be of interest at this point to state that all of the quotations made above from college catalogues, for the purpose of illustrating "denominational" practises of colleges, have been made from the catalogues of colleges disclaiming in those very catalogues that they are denominational colleges.[1]

Subtracting these from the number of non-sectarian institutions given in the U. S. Rep. and adding it to the number of sectarian ones there given, we then obtain the following more nearly correct statistics concerning the total 672 colleges and universities of the United States:

Public (52)			Private (620)			
National	State	City	Non-sectarian	Sectarian 461		Not Investigated
				Sectarianism admitted, 417	Sectarianism denied, 47	
2	46	4	16			Thirty-three women's colleges of secondary rank.
($\frac{3}{10}$%)	(7%)	($\frac{3}{5}$%)	($\frac{1}{3}$%)	74½%		Seven colleges of primary rank.

What are the general conclusions to be drawn? It is evident that one of two things must be done. The denominational college must be entirely supplanted by the state college, placed in as numerous and methodical branches over the United States as are the high schools and grade schools at present. In each community of a certain number of

[1] The references for these quotations are as follows: Iowa College Bulletins, Vol. V., No. 2, pp. 7–8; No. 3, p. 4. Wellesley College Calendar, 1905–6, p. 21. Wabash College Catalogue, 1906, p. 11. Colorado College Catalogue, March, 1907, p. 120. Smith College Official Circular, Series 1, No. 2, 1905–6, p. 11. Western Reserve University (College for Women) catalogue for 1906–7, p. 59. Princeton University Catalogue, 1906–7, p. 255. New York University Catalogue, 1905–6, p. 179. Bryn Mawr Program, 1906–7, p. 45. Amherst College Catalogue, 1906–7, p. 6.

inhabitants there should as regularly be a good public college as there is now a public high school in each similar smaller community. Besides federal and municipal institutions there should be national ones, not of the same grade, but for entrance to which graduation from a federal institution might be a prerequisite. Whether these suggested institutions should come into existence by taking over the "plants" of the present denominational colleges or by some other method need not be worked out in this article. Ways and means can always be discovered when an act is recognized as a necessary one.

If this is not done, there is but one alternative. If the denominational colleges continue to exist, and to combine general training and education for citizenship with religious instruction, basing such religious instruction upon the contents of the accepted book or books of any religion, or the interpretation of these books by any church or personal interpreter, or propound any more definite monotheism than the motto on our coins, "In God we trust," and if these colleges continue to be exempt from taxation then we must at once and forever abandon the pleasant fallacy that in the United States church and state are independent.

THE TRIAL OF AN OLD GREEK CORN-RING

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LITTLE Greece contributed to civilization the most precious thing in the world—fearless freedom of thought. That novelty, it is true, kept the various city states from uniting as a mighty power, but that same disunion made the individual man and the individual mind superior to the dead level that saps the genius of progress. That active principle of the pioneer the Greek infused into his jurisprudence with the same telling success that stamped his efforts in the other departments of human advancement.

Though the system may have occasionally miscarried from its own weight, failure to protect the life, liberty and property of its citizens was not one of the faults of the Hellenic democracy. When Solon, in the sixth century before Christ, originated at Athens his system of trial by popular courts of jurymen-judges, he not only laid the foundation of national law but discovered the real secret of democracy, which is and has been the keystone of European and American institutions; for the hope of a free people lies in the possession of its courts.

Down through the brief but brilliant period of their political prestige, the Athenians laid many a wreath at the feet of the lawgiver, Solon, but probably never more reverently or more gratefully than when the commonwealth fought that still unfinished fight with the speculator and monopolist of the food-products of the nation. So that this review of the legal principles and procedure in the prosecution of an old Athenian corn-ring may be of interest and even of value to the historian and economist, the lawyer and patriot.

The oration with which this review deals is a speech for the prosecution, numbered 22 in the ordinary collection of speeches by Lysias, the celebrated Athenian speech-writer, and dates from the early part of the fourth century, possibly 387 B.C. To get a sympathetic setting, it is advisable to recall the appointments of the old Greek court, the laws and legal customs, as well as the peculiar, though not necessarily unique, conditions that dictated the legislation on which the prosecution relies.

Though no actual law has come down to us, the whole procedure in the Athenian courts—to say nothing of the evidence of Quintillian—shows that the law required every citizen to plead his own cause.

And this was no harsh provision before the birth of rhetoric and logic when natural eloquence alone existed and professional oratory was not dreamed of. The establishment of the popular courts and the above requirement changed the literary vehicle from poetry to prose, as a mode of expression better adapted to argument and logical treatment, and finally the professional rhetorician came into the field just after the death of Pericles, that eloquent political "boss" of Athens. At this time, Gorgias, the famous Sicilian orator, showed the Athenians, as embassador, the miraculous possibilities of their language and it at once became the style to cultivate oratory as a fine art. The ordinary man was now severely handicapped in a contest at court with a pupil of the professional rhetorician and lack of time, inclination or ability forced the suitor, if himself unskilled, to hire a logographer or speech-writer to prepare his speech for delivery.

The logographer wrote the speech and gave his client (if we may so call him) some instruction in general delivery. He was not a lawyer, in our sense, his duties ceasing when the case came to court; though at intervals, we find a "next friend," who serves as assistant speaker without pay. The speech-writer did not appear in a professional capacity and the delivered speech disclosed no identity which suggested a violation of the laws on pleading and practise.

The first logographer who wrote for pay was the orator, Antiphon, the master of criminal law. Isæus has left us an extended collection of his speeches, drawn up for suitors in inheritance cases. Demosthenes, after being looted by his guardians, took to speech-writing as a livelihood and laid the foundation of a greater fortune than the one he had lost. Lysias, a reduced metic (resident alien) at Athens, whose property had been confiscated by the "Thirty Tyrants," was probably the most famous and cleverest speech-writer of his times, if we can take Plato's word (Phædrus 228A). His character-study of the manners and mannerisms of the actual suitor was so thorough that the delivered speech became the apparent thought and word of the pleader himself. Not being a citizen, Lysias was practically out of politics and political speeches and so confined his attention to the remunerative preparation of the private speeches of those who wished to win their case. The senator who prosecutes the grain-dealers evidently considered that, in obtaining the services of the expert Lysias, he was doing all in his power to aid the public weal and to protect and enhance his own civic and political reputation.

While undoubtedly Lysias was "for the prosecution,"—whether that word is interpreted to mean the unknown senator or the state—we know nothing of the counsel for the defense—unless we have a right to infer that the corn-ring employed the regularly, though stealthily, retained, "corporation" defense-writer.

The case against the corn-ring was tried in one of the ten Heliastic (jury) courts, located in the market place at Athens, to the north of the Acropolis and Areopagus, those hills dedicated to religion and homicidal law. These courts of sworn jurymen-judges were higher courts and though apparently no appeal would lie from their decisions, some revisory power did exist, at least in the way of bringing new suit and being allowed a new trial before new jurymen-judges, on discovery of false testimony that had influenced the verdict, excusable defaults, etc.

An apparently large number of cases was settled by private and public arbitrators, the parties in interest ordinarily binding themselves to abide by the decision given. Besides family and friendly arbitrators, whose services were most widely sought and employed, there was a regularly established system of public arbitration, whose officials, chosen annually, by lot, were over fifty years of age. To these officials magistrates could refer any private suit, though from their findings appeal and recourse to a regular jury-trial in the higher court could be claimed. A fee was charged on each party. Criminal and public prosecutions, like the present, would not, from their very nature, come before the arbitrators, but be brought, in regular course, before the Heliastic jury, as noted below. The orators are continually emphasizing their offer of arbitration or criticizing their opponent's lack of it and it appears to have been a legal principle and honored custom to avoid litigation by attempting to settle all possible cases "out of court."

Such procedure would tend to greatly relieve congestion of cases, so that the "Law's delays," so fertile a source of modern criticism, would be reduced to a minimum, which must have become practically *nil,* when the statute became operative which limited the trial of a case to one day's time. There was, apparently, some fault found with this limitation; for Plato, in the "Apology" (37A), makes his beloved master, Socrates, say: "I don't believe I have intentionally wronged any man, but I am not persuading you of that; for we have been conversing with each other but a short time. But, as I think, if you had a law like other men, that the verdict in capital cases was not required to be given in one day but many days were allowed for the trial, you would have been persuaded."

But such extreme limitation seems no unhealthy prohibition, philosophers to the contrary notwithstanding, especially when we realize that at the preliminary hearing (the anácrisis) before a magistrate, all the evidence that each side had to offer—laws, decrees, documents of all kinds, oral testimony of witnesses, affidavits of commissioners, evidence of slaves given under torture—was reduced to writing and deposited, under seal, by the magistrate, in the "Hedgehog Box" (*bristling* with documents), to be kept in safety till the sacrifice and

herald's prayer opened the trial on court-day. So that the speeches for the prosecution and defense and the decision of the jury virtually comprised the whole trial. This evidence, previously reduced to writing, was merely read by the clerk before the witness who stood on the speakers' platform and acknowledged his testimony. The direct and cross examination of the witnesses at the trial proper, was thus avoided and the time consumed in putting questions to one's opponent, who was obliged by law to answer, was but a small set-off to the time gained by thus preparing material beforehand. The prompt decision of a higher court, especially in a case so vital to the interests and even life of the citizens as this against the corn-ring, would be of immense benefit and must have been a procedure resulting from years of carefully considered legal and political experience.

And too, a prospective prosecutor might well hesitate to bring a public suit when he considered the penalties to which he would be liable if he failed to prove his case. Our senator, however, could be fully assured of the sympathy of the public and of enough votes from the jury to relieve him of anxiety in regard to obtaining the necessary one fifth of the total vote cast. Failing to receive the required number of votes, payment of all costs and expenses was exacted together with a fine of 1,000 drachmæ or $180, which would purchase ten-fold more than at the present day. Add to this, the partial loss of citizenship, so far as the right to again bring similar suit is concerned, and we realize the seriousness of a public indictment for the plaintiff, as well as the effort of the Athenian legislator to prevent litigation among a people with such a mania for law that a character in Aristophanes's comedy did not believe that the country, pointed out on the map, was his native Attica because he couldn't "see any lawsuits going on."

As breaking the corn laws was a crime against the state no "summons" like that in a private suit was required, but the accusation was first laid before the president of the Boulè or unicameral senate,[1] who referred the matter to the senate, in session, which then held a "hearing" which took the place of the "preliminary hearing" in the private case before the magistrate, noted above. If the senate favored the accusation, a resolution was passed to that effect, and the clerk notified the Thesmothetæ of the result of the "hearing," submitting therewith the evidence of which the latter might take official notice. It then became the duty of these officials to bring the case for actual trial before a jury. The Thesmothetæ, who were associated with the chief magistrates of the nation, were a board who had the supervision of the whole judicial system at Athens and, in that capacity, examined and noted defects in the laws and kept a record of judicial decisions. These six junior archons presided at the trial in great public cases like the present

[1] Lysias, Oration 22, Sec. 2.

one, but only as formal chairmen, and did not in any way assume any of the functions of the jurymen-judges, whose decision covered both law and fact. The senate could not legally deprive a defendant of a trial by a jury of his peers, and no instance occurs of the assumption of such powers, except under the constitution-breaking "Thirty Tyrants" or by some patent violation of the legal rights of the citizen, though it was the ultimate court in public cases settled by a fine.

The jury, in the present case, would differ from our common law jury to-day not only in its wider function of judging both law and fact, but in the number of its members and the mode of rendering its decision. Any full-fledged citizen who signified his desire to serve by placing his name on a list of would-be jurymen, was entitled to be enrolled as juror, if he was over thirty years of age and the lot chanced to fall on him.

At the beginning of each official year, five thousand jurors were selected by the Thesmothetæ by lot. The jurymen were sworn in immediately after this general list was drawn, before being assigned to any particular case. The exact nature of the juror's oath, at the time the suit against the corn-ring was brought, is uncertain, though it probably did not differ materially, if at all, from that preserved in Demosthenes's speech, "Against Timocrates"[2] a generation later. The following is a careful translation of that interesting legal relic, with its searching appeal to the juror and citizen, who swears to defend the constitution.

OATH OF DICASTS (JURORS)

I will vote in accordance with the laws and decrees of the Popular Assembly of the Athenians and of the Senate of the Five Hundred.

That there should be a tyrant I will not vote nor an oligarchy; nor, if any try to abolish the Popular Assembly of the Athenians, or speak or put to the vote aught contrary to these things, will I hearken to him.

Nor a cancelling of private debts, nor a redistribution of land or houses of the Athenians.

I will not recall those in exile nor those on whom sentence of death has been passed. Neither those who are abiding here will I banish contrary to the existing laws and decrees of the Popular Assembly of the Athenians. I will not do so myself nor suffer others so to do.

I will not confirm an office so that a man hold it while still liable for his audit for a former office, whether one of the Nine Archons or Sacred Recorder or whatever offices are balloted for the same day with the Nine Archons, whether herald, ambassador or deputies.

I will not vote that the same man hold the same office twice nor that the same man hold two offices in the same year.

I will receive no gifts on account of my service in court, neither myself nor any other man or woman for me, if I know it, by any means or contrivance whatsoever.

I am not under 30 years of age.

[2] Demosthenes, Oration 24, Sec. 746.

I will listen to the plaintiff and defendant both alike.

I will give my vote on the question at issue and none other.

I swear by Zeus, Poseidon, Demeter; I invoke utter destruction on myself and my household, if I transgress any of these things and many blessings, if I keep my oath.

The jurymen, thus drawn and sworn, were divided into ten panels of five hundred each. Each person, drawn, received a ticket of box-wood or bronze inscribed with his own name, that of his father, his residential district (the three essentials required for the legal designation of a free citizen) and the number of his panel. Such tickets of bronze, with the Gorgon's head and the omnipresent, Athenian owl—the official bird—are still extant.

Each panel was made up of members of all ten Athenian tribes, thus reducing to a minimum religious and residential prejudice and favor. The smallest number on any one case mentioned by the classic authors is two hundred, but we find cases with five hundred (trial of Socrates), one thousand, two thousand and even as high as two thousand five hundred jurymen-judges. An odd man seems generally to have been added to break a tie vote, though from some remarks dropped by the orators, we can infer that an even vote would mean the defendant won. The number which sat on the jury in the prosecution of the corn-ring is not known, but from the number assigned to other cases of similar importance there must have been a jury of a thousand or even two thousand men, as in the political trial of the informer, Agoratus, by the restored democracy after the expulsion of the aristocrats.[3] The theory underlying these great juries was that they were the largest possible representative committees of the whole Athenian democracy, with the delegated powers of the body-politic, the nearest approach to trial by the whole people. And, too, large juries were safer as a protection against bribery—that nightmare of the Athenian patriot. With the American reluctance to serve on the jury in mind, we instinctively ask how such large panels could have been obtainable. The answer is found in the fact that the Athenians were the most litigious people in history, loved the popular law-courts as the safeguard of their constitutional liberty, and were furnished by Pericles and the great political bosses after him with sufficient pay for their services to provide a living to the poor Athenian from jury service alone, to say nothing of becoming the political equal of the richest or most aristocratic citizen. The Athenian seemed to realize, in unique fashion, that the hope and redress of a free people lies in the possession and use of its courts, and they were so eager to attend trials and serve on juries that the conservative Aristophanes satirized the typical Athenian disease of law-mania. In the "Wasps," the comic poet, in trying to ridicule popular juries, especially those of the paid and

[3] Lysias, Oration 13, Sec. 35.

democratic brand, has given us an amusing study of the law-frenzy of the old juryman, Philocleon (Boss-Lover), who could not be kept away from court, though his son and two slaves net the house, from which the infatuated juror tries to escape through the chimney, by the rain-gutter, concealing himself under an ass that is being driven to market. The chorus of elderly jurymen come to "Boss-Lover's" assistance and finally compromise the matter by having the old man go back home and hold a private trial of the dog, Labes (Snap).

The case and the court house, in which any particular panel was to serve, was unknown till early in the morning of the day set for trial, when our jurors presented themselves and their bronze tickets, showing they had been drawn on the general list, and were then assigned by lot to their work for the day. The corn-ring jury then went to the "Middle Court" or the "Red Court," or "Hole and Corner Court," "Music Hall Court," to the "Painted Colonnade," or to one of the other five courts, all with different names and door-ways of different colors. On receiving his assignment, the juror took the staff of the proper color and was immediately escorted to the court to match and, at his entrance there, gave up the staff, getting in exchange a check which, at the close of the day, was good for his fee of three obols or nine cents, which slave labor and low costs of living made many fold more than the mere amount indicates.

The appointments of the court room consisted of an altar for sacrifice, raised platforms for the presiding officials, for the parties to the suit and the witnesses. A statute of Lycus, patron-god of jurors, a water-clock to time the speeches and a table with the two voting-urns thereon probably completed the furnishings at the period when our case came on. Order was kept in court by Scythian slaves, detailed from the regular police.

After the speeches were made, the case was given to the jurymen-judges, who always rendered their verdict without leaving the court-room but, however, with the utmost secrecy. The mode of voting was simple and, though secret, was open to the fullest scrutiny on the part of the spectators. A person, chosen by lot, distributed bronze discs, pierced by protruding axles, all exactly alike, except that the ballot for the plaintiff had a hollow axle and that for the defendant a solid one. Specimens of these ballots, marked "public ballots," are still extant. The herald proclaims "hollow ballots for the plaintiff; solid ones for the defendant"; hence hollow ballots meant condemnation, in the prosecution of the corn-ring, and solid ballots meant acquittal. Our juryman concealing the ends of the axle with thumb and forefinger, at the herald's notice, proceeds to the table and deposits in a bronze urn the ballot with which he wishes to record his verdict, casting the unused ballot into a wooden urn. The ballots are counted by the

presiding officials and the result is immediately announced by the herald. Under the system, to say nothing of the natural feeling in this case, there were no delays resulting from the failure of the jury to agree; for a majority-vote decided the verdict.

The penalty, in this case, was fixed by law—which did not always happen—and, in default of a fixed penalty, not only actual damages but the penalty also was a matter for the jury to assess.

Athens and the Attic country-side, bounded by the mountains and the Greek seas, were practically insular when the supply of wheat was considered. A little nation, with only half the area of Rhode Island but equal in population to that thickly settled commonwealth, would thus present problems in plenty and corn-laws galore. The unproductive, light soil caused Solon early to forbid the exportation of any farm product except olive oil; while the export of native grain was absolutely forbidden by law, with the consequent encouragement of the importation of cereals. Bread-stuffs must, in the main, come from abroad and the fertile fields of Egypt and Sicily, to say nothing of Rhodes and Cyprus, and, above all, the Black Sea country of modern Russia were drawn on. The great problem in war, as well as in peace, was to keep open a way for the corn-merchantmen, especially to that north country; and on the failure or success in that vital work lay the hope or despair of the Greek admiral or ruling statesman. Foreign princes wooed the Athenian populace with presents of corn and Harpalus, afterwards treasurer of Alexander the Great, won citizenship at Athens by a gift of corn.

Forced importation of grain was a cardinal principle of Athenian economics, politics and law. The speeches of the "orators" are full of regulations, restrictions and enactments, rigorously and mercilessly enforced, against the dreaded day when city-folk and farmers alike might see starvation at their doors. Both Athenian citizens and metics (resident aliens) were forbidden to ship grain elsewhere than to Attic ports or to lend importers money on vessels unless the mortgaged cargo was to put in to the Piræus, harbor-town of Athens. Another law required that at least two-thirds of the cargo of every corn-ship that touched at the port must be carried to the city. The popular assembly called for reports and demanded provisions for a supply of grain at its monthly sessions.

Among the numerous corn-laws, one, intended to prevent speculation and the artificial raising of the price of grain, went directly to the heart of the traffic by prohibiting retail dealers, on penalty of death, from buying more than fifty *phormoi,* or baskets, at any one time. The *phormos* was a measure equal to about a bushel and a half and the consequent seventy-five bushels—to the purchase of which each retailer was limited on any one day—was probably a sufficient stock in trade

and, if enforced, a reasonable safeguard against "a corner in corn." The severity of the penalty imposed in this case by the law of the land, is remarkable, especially as the Athenian law seldom imposed the death-penalty at all; banishment, disfranchisement, etc., being preferred as potent purifiers of the body-politic. If the evil was driven out of the state, the state was the better for it. The control of such a small nation by a "ring," guild or corporation of tradesmen was easy, by virtue of its narrow boundaries, and, for that reason, heavier penalty and more rigorous control is imperative. The easier the violation, the greater is the temptation and consequent danger to the commonwealth. A twenty-nine million dollar fine would have been impossible, but the death-penalty was a more direct and persuasive inducement to respect for the public weal; and though the risk was still run by greedy speculators, as our speech informs us, the law, made by the people, for the protection of the people, was enforced by a jury of the people, though they must in the discharge of their duty send the guilty to the fatal draught of hemlock.

A special board of ten corn-commissioners, elected annually by lot, had charge of the enforcement of the above law, under which our senator prosecutes the "corn-ring." It was the duty of the board to see that the unground grain was for sale in the market at a fair price; that the millers sold the meal at a price proportionate to that of the corn; that the bakers sold bread at a price proportionate to the price of wheat and made their loaves of bread of a weight fixed by the corn-officials.[4] These officers were also required to keep an account of all importations of grain.[5]

The grain dealers or retailers were the middlemen between the people and the great wholesalers or importers, and we may trust them to evade the law by secret understanding with the importers in regard to buying in bulk; by combining with each other to buy low, hold and sell high; by raising the price by circulation of news of war, storm, wreck, etc., as we learn from the orations of Demosthenes and Lysias. Such are the legal principles, laws and procedure underlying the case which our senator brings in his prosecution of the Athenian "corn-ring" for illegal speculation.

The senate, in such cases, ordinarily chose a public prosecutor to defend the interests of the state. Our senator may have been glad to assume that position as a willing choice, as he intimates, to clear himself of the suspicion of being "in with the Ring."

The speech itself is brief and logical, clearly stated and forcibly argued, and sticks closely to the point at issue—a proceeding that did not always obtain in the Greek law suit, though that blemish is not entirely unheard of in our modern courts, at least by inference, which

[4] Aristotle, Resp. Athen., 51, 3.

[5] Demosthenes, Oration 20, Sec. 32.

sometimes gets in where direct statements fail to enter. The speech, a master-piece for a conservative, public-spirited business man, is a fine example of Lysias's character-study. The defendants admit their guilt and apparently try to avoid the consequences by pleas in confession and avoidance. The pleas in excuse were (1) that the corn-inspectors suggested that the dealers buy up the corn; and (2) that their action had benefited the public by obtaining for it a supply of grain. Our senator replies (1) by showing, on evidence, that the corn-inspectors never made any such suggestions and that if they did it would not excuse such an open violation of a plain law; and (2) by showing that the rôle of public benefactor could not be very seriously assumed by men who "dodged taxes" and the other patriotic contributions and raised the price of corn in one day many fold higher than the law allowed.

Liberal extracts of the speech itself in the words of the old Greek senator follow:

Many have come to me, gentlemen of the jury, wondering at my accusing the grain dealers in the Senate and saying that no matter how guilty you thought they were, you would nevertheless consider those who made speeches against them, blackmailers. Now I want, first of all, to tell you why I was compelled to accuse them. When the presidents brought the charge before the Senate they were so indignant with the dealers that some of the speakers said they ought to be turned over to the "Eleven"[6] and put to death without a trial. But I, thinking it was a terrible thing for the Senate to get in the habit of doing such things, got up and said that it seemed to me that the grain-dealers should be tried according to law, considering that, if they had done things which deserved death, you would give them their just desserts just as well as we; but if they had done no wrong there wasn't any need of our putting them to death without a legal trial. And although the Senate was persuaded of this, some tried to accuse me, saying I made my speech to save the grain-dealers. Now before the Senate, when the "Hearing" was held, I made a practical defense against these charges; for when the others kept quiet I got up and accused the dealers and made it clear to everybody that I had not spoken in their behalf but for "due process of law." Now I started in this affair for the reasons I have described (from fear of the charges against me), but I consider it disgraceful to stop till you have voted what you wish to do with them.

The plug is put in the water-clock and the flow of water, which regulates the time for speaking, is stopped, while one of the defendants is put on the stand.

First you come up and take the stand. Tell me, are you a metic [resident alien]? Yes. Do you enjoy the privileges accorded to the resident alien on condition that you obey the laws of the city or with the understanding that you do whatever you please? On condition that I obey. Don't you expect to die if you have done anything in violation of the laws for which the penalty is death? Certainly. Now tell me if you admit that you bought up more than the seventy-five bushels which the law provides as the limit permissible? I bought at the bidding of the officials.

[6] Board of prison and police commissioners in charge of executions, etc.

After this, rather evasive, reply the water-plug is removed, the water runs anew and the senator replies to the first plea, noted above:

If he can show, gentlemen of the jury, that there is a law which requires the corn-dealers to buy up corn because the officials bid them to, vote to acquit them. But if he does not, it's only just that you vote condemnation; for we produced the law which forbids any one in the City buying up more than seventy-five bushels of corn. Now this accusation ought to be sufficient, since this man admits he bought it, the law clearly prohibits it and you have sworn to vote according to the laws.

However, to persuade you that they are lying about the officials, I must speak more at length about them. Now when these fellows put the blame on the officials we summoned the officials and questioned them. Four said they knew nothing about the matter and Anytus said that during the previous winter, when corn was high and these fellows were bidding against each other and fighting with each other generally, he advised them to stop their wrangling, thinking it to the interests of you who buy from them, that these dealers should buy as low as possible; for they've got to sell it higher than cost, if it's only a penny more. Now to prove that he did not order them to buy up corn and store it away but did advise them not to bid against each other, I will furnish Anytus himself to you as witness; and to prove, too, that he spoke these words under the former Senate and that these fellows appear to have bought it up this year. "*Testimony* (Read and acknowledged)." Now you've heard that they did not buy up the corn on orders from the officials. But I think, if they are really telling the truth about the corn-inspectors, they will not be defending themselves but be accusing the officials; for in matters which the laws have expressly provided for, why shouldn't both those who fail to obey and those who incite them to act contrary to the laws, pay the penalty?

The senator then replies to the second plea in excuse which admitted that they had "cornered" the supply but held their action had really benefited the people. This prototype of the modern trust-lover's argument is logically decapitated and the disguise of public benefactor is torn off in brief but telling language which exposed variation of price in a single day—the most charitable explanation of which was that the price changed as the "bulls" or "bears" respectively controlled the market. The senator also took the opportunity to impress on the "corn-ring" that obedience to the laws and willingness to make the patriotic contributions the nation called for was a condition precedent of loyalty and that charity in trade may be allowed as a supplement, but not as a substitute for the performance of duty to one's country and fellow citizens.

But, gentlemen of the jury, I don't think they will get any pity for such talk. And perhaps they will say, as they did in the Senate, that they bought up the corn out of good will towards the state, so that they might sell as low as possible. But I will offer you the greatest and most evident proof that they are lying. For if they did do it for your sake they would have appeared selling for many days at the same price, until the corn they bought up gave out; but now, as a matter of fact, at times on the same day they sold at a drachma [18 cents] higher than at other times—just as if they had bought by the bushel and not by bulk. And I furnish you witnesses to prove it.

And it seems to me an awful thing that they don't want to contribute to the war-taxes, when necessary—and that's a thing everybody is going to know about—and plead poverty; but where there was a death-penalty and it was to their interests to keep things "dark," this they say they did in defiance of the law out of love for you. And you all know that such talk as that does not become them at all; for their interests and those of other people are radically different. For they make their biggest profits when they sell corn higher to the State on some report of evil. And so glad are they to see your mishaps that they know about them before other people and make up stories and circulate them themselves, saying that the ships in the Black Sea have been wrecked or those which have put to sea have been captured by the Spartans, or the ports have been blockaded, or the truces are about to be annulled; and have come to such a pitch of hostility that they plot against us at the same critical period that the enemy does. For when you especially need grain these fellows "snap it up" and refuse to sell so that we may not haggle over the price but may think ourselves lucky if we get off with buying from them at any price whatever; so that sometimes, even in time of peace, we are besieged by them. . . . Frequently, before now, you have inflicted the most severe penalties on the officials—and that too, though they were citizens—because they could not control the rascality of these men. What, pray, ought the malefactors themselves to suffer at your hands when you killed those who were unable to guard them?

Calling upon the jurymen to regard this as a "test case"—as the people surely will—to chastise the guilty and protect their victims, with an appeal to justice and an argument to catch the crowd, our senator closes this speech of such vital interest to the people of constitution-loving and law-enforcing Athens.

You ought to consider that it's impossible for you to vote acquittal; for if you acquit men who confess they "combined" against the merchants, you'll seem to be plotting against the importers yourselves. But if they had made any other defence no one could have found fault with a jury who acquitted them; for "it's up to you" to believe whichever party you wish. But now, won't you seem to be doing something awful if you let men go scot-free who confess they violated the law?

Now, gentlemen of the jury, I think it's clear to everybody that law-suits on such matters are of the most general interest to the citizens, so that they will learn what opinion you hold about them, thinking that if you condemn these fellows to death, the rest will be more orderly and law-abiding, but should you let them go scot-free, you will be voting them full immunity to do whatever they please. You ought, gentlemen of the jury, to chastise them, not only for the past but as a warning for the future; for in that case even, they will be barely endurable. . . . And should they beg and implore you, you would not justly take pity on them but far more on those of the citizens who are dying through their rascality, and on the importers against whom they have "combined," whom you will please and make more zealous if you punish these fellows. But if you do not, what opinion do you think they will have when they learn that you acquitted the hucksters, who admitted they conspired against the importers?

I don't know what more I ought to say; for about other malefactors, when they are on trial, you must get your information from the accusers, but all of you know the rascality of these fellows. At any rate, if you convict these men you will "do the square thing" and you'll buy your corn lower; but if you don't, it will be higher.

THE POPULATION OF THE UNITED STATES

By Professor JAMES S. STEVENS
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OF all branches of statistics, those which relate to the population of a country or city are of most general interest. The interest felt in the question of our national population culminates every ten years when the census is taken. To be sure, no great importance is to be attached to mere numbers; yet we can not help feeling a little pride if we belong to the biggest religious denomination, the biggest university, or the biggest country.

The plots in Fig. 1 represent the growth in population of various countries as indicated by the census of 1900. The curves were made by Mr. W. R. Wilcox and were printed in the census report for that year.

An examination of these curves shows that for the most part the growth of a country is constant; for example, the lines representing France, Spain, Sweden and Norway, Turkey and Italy, are nearly straight. This indicates that while the population of those countries is increasing slightly, there is no great gain from year to year. The population of the United States is represented by a curve which is well known in mathematics. In the chart below I have redrawn this curve, and with it one which is a true parabola.

It will be seen that these two are strikingly similar. Now if the population of the United States increased in such a manner as always to follow this parabolic form, the census enumeration would be unnecessary, as one could predict the future population from the past. Unfortunately, however, this is not the case; and it is only by a somewhat tedious method that we are able to predict the future population with any degree of certainty. There are two kinds of formulæ—rational and empirical. A rational formula is one which is mathematically true under all conditions. The fact that the volume of a cylinder equals π multiplied by the square of the radius, multiplied by the length, is a fact that does not depend upon any external circumstances whatever. On the other hand, the value of the acceleration due to gravitation is not a constant quantity, but differs with the latitude and altitude of the observer. This latter is one of the most important physical constants in nature and a great deal of time and money have been expended in determining its value. While there is no mathematical formula that expresses this value, an empirical formula has been devised in which, if one substitutes the latitude and altitude of the place of observation, a

close approximation of the value of this constant may be obtained. To take another illustration: The relation between the velocity of water flow to its depth below the surface in a river is not a constant one, but

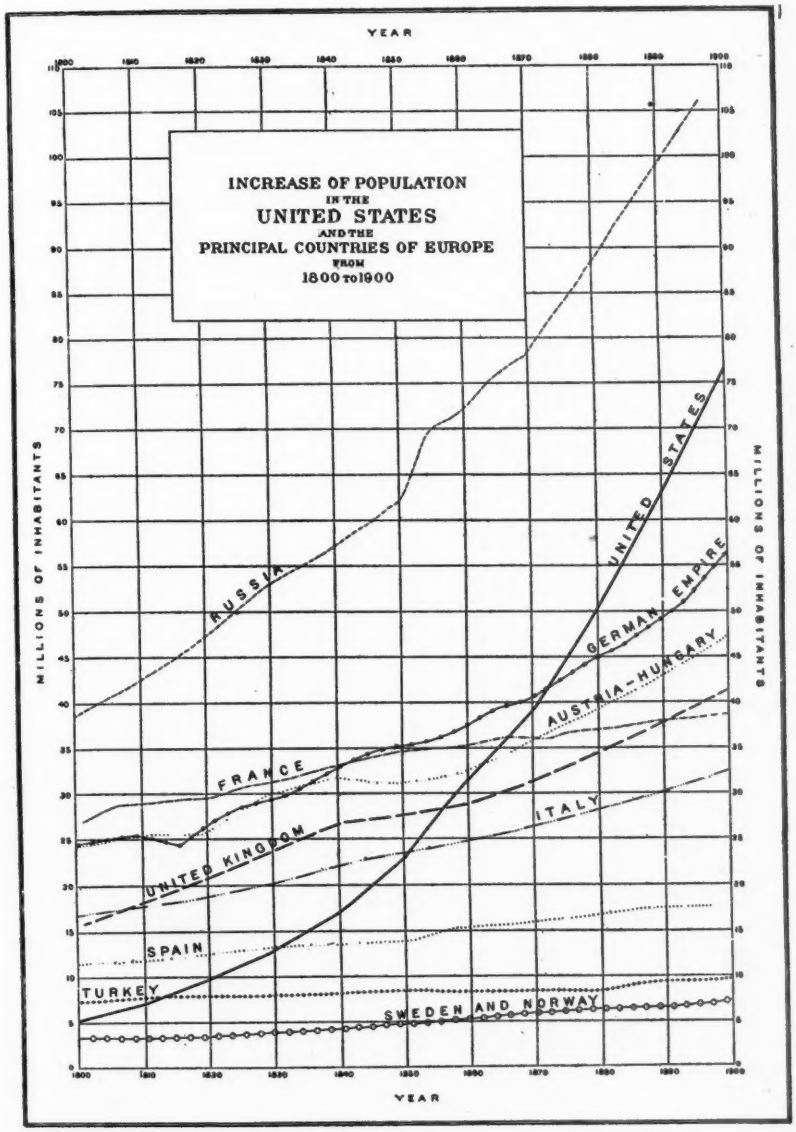

FIG. 1.

repeated measurements have shown that by the use of an empirical formula containing certain constants, this relation may be quite well established. On the other hand, the relation between the space passed over by a freely falling body and the time of its fall is a perfectly

definite one, and may be correctly expressed by saying that the space passed over varies as the square of the time.

These illustrations will be sufficient to make clear the distinction between mathematical and empirical formulæ. It will be hardly necessary to state that the growth of a country in population follows the lat-

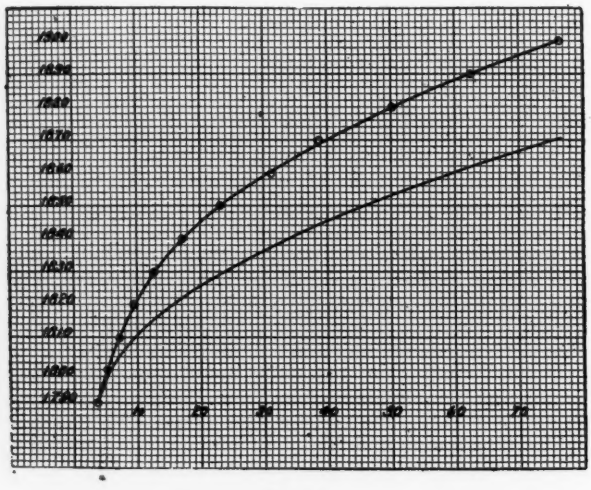

FIG. 2.

ter rather than the former. In order to predict the future population, it is necessary to determine what kind of a curve the previous numbers representing the population will plot. As has been stated above, this curve comes out a parabola and the equation for this parabola is

$$P = S + TX + UX^2.$$

There are also certain terms of higher orders which may be omitted. In this equation, P represents the population at any time, X the number of the decade and S, T and U are constants, which are to be determined. The determination of these constants involves a somewhat technical process, which may be briefly stated as follows: We first write down the population of the United States for each decade since the census began to be taken.

Year	Population	Year	Population
1790	3.9 millions	1850	23.2 millions
1800	5.3	1860	31.4
1810	7.2	1870	38.6
1820	9.6	1880	50.2
1830	12.9	1890	62.6
1840	17.1	1900	76.3

From these observations we form what are called "observation equations" by substituting for P and X their proper values.

These observation equations follow:

1	$3.9 = S + 0 + 0$	7	$23.2 = S + 6T + 36U$
2	$5.3 = S + T + U$	8	$31.4 = S + 7T + 49U$
3	$7.2 = S + 2T + 4U$	9	$38.6 = S + 8T + 64U$
4	$9.6 = S + 3T + 9U$	10	$50.2 = S + 9T + 81U$
5	$12.9 = S + 4T + 16U$	11	$62.6 = S + 10T + 100U$
6	$17.1 = S + 5T + 25U$	12	$76.3 = S + 11T + 121U$

Normal equations for each constant are formed from these observation equations by multiplying each equation by the coefficient of the constant concerned in the equation and adding. This gives us three equations containing three unknown quantities. These unknown quantities are determined by any method and substituted in the general formula for S, T and U, respectively. For example, in 1900, before the census returns for that year were available, the process above outlined yielded the following equations:

$$\begin{aligned} 261.7 &= 11S + 44T + 286U \\ 1669.5 &= 44S + 286T + 2026U \\ 12324.1 &= 286S + 2026T + 15334U \end{aligned}$$

When these equations are solved, it is found that

$$S = 6.08, \qquad T = 0.690, \qquad U = 0.622.$$

If we substitute these in the formula, we get

$$P = 6.08 + 6.9 + 62.2, \quad \text{or} \quad P = 75.2 \text{ millions},$$

which is the forecast for 1900.

(It should be observed that in this work the year 1790 was considered -1, and 1800 was taken as the origin.)

This estimate proved somewhat low, as the census returns reported 76.3 millions for 1900. This indicates that the population of the country is growing a little more rapidly than would be indicated from its past history.

While the government authorities are at work on the census for 1910, it will be interesting to try this method of forecasting, and to see how well our results will compare with those to be announced later on. I have made a number of equations which are supposed to represent empirically the growth of the population of our country. These have been made in various ways, but all depend upon the parabolic formula, and the method outlined above.

A.	$P = 5.13 + 0.358X + 0.666X^2$	D.	$P = 5.30 - 0.20X + 0.73X^2$
B.	$P = 5.30 + 0.49X + 0.65X^2$	E.	$P = 5.40 + 0.12X + 0.70X^2$
C.	$P = 4.90 + 0.45X + 0.66X^2$	F.	$P = 39.1 + 10.45X + 0.65X^2$

The equations yield the following values for the census of 1910:

A. $P=89.7$	C. $P=89.7$	E. $P=91.4$
B. $P=89.3$	D. $P=91.4$	F. $P=91.3$

It will be observed that these forecasts fall into two classes, in one of which the numbers run between eighty-nine and ninety millions and the other a little over ninety-one millions. The former are based more strictly upon the formula as it stands, including the entire set of observations. In the latter, greater weight is given to more recent observations, as it is supposed that they represent more nearly the present rate of increase in the population. The last formula (F) is based upon three observations only, those for 1880, 1890, and 1900. It is probable that while the formulæ yielding the lower results conform more nearly to the population of our country in the past, the results which are yielded by the other set of formulæ are more correct for 1910. As an illustration of the closeness with which the formulæ conform to past conditions, we will determine the results for each census by means of formula:

$$P=5.13+0.358X+0.666X^2.$$

Year	P (Census)	P (By formula)	Difference
1800	5.3	5.3	0.0
1810	7.2	6.2	1.0
1820	9.6	8.5	1.1
1830	12.9	12.2	0.7
1840	17.1	17.2	0.1
1850	23.2	23.6	0.4
1860	31.4	31.3	0.1
1870	38.6	40.3	1.7
1880	50.2	50.7	0.5
1890	62.6	62.4	0.2
1900	76.3	75.4	0.9
			6.7

The formula published by Dr. H. S. Pritchett, in THE POPULAR SCIENCE MONTHLY, of November, 1900, agreed more closely with the results of past censuses than the one used here. It will be noted that while the sum of the various deviations resulting from each application of the formula is 6.7 millions, that from Dr. Pritchett's formula is only about 4 millions. This formula, however, does not seem to fit the future conditions so well as the one employed here, for it gives a population of 77.5 millions for 1900, while the census returns show it to be 76.3 millions.

As a method of determining the population of the United States during the coming decades, the application of these formulæ is interesting. By the use of formula E—

$$P=5.4+0.12X+0.7X^2$$

we obtain the following forecasts:

1910	91.4 millions	1970	209.7 millions
1920	107.6	1980	234.4
1930	125.3	1990	260.4
1940	144.3	2000	287.8
1950	164.7	2500	3,443.8
1960	186.5	3000	10,099.8

Since one of the factors used in the formula is a square, it is noticeable that the increase is quite a rapid one as the years go on. In the year 2270, which is not so very remote, the estimate is 1,557 millions, which is about the population of the globe at the present day. The predictions reached by this formula are somewhat smaller than those given by the formula of Dr. Pritchett in the article referred to. An interesting point in the curve is noticed for the year 1870. It will be observed that the population for this year differs more widely from that of the predicted population than that for any other year. This is probably due to two causes. In the first place, the effects of the civil war are shown in the reduction of the population, and, secondly, it is probable that the census of 1870 was not so accurately taken as that of any other decade. This latter reason is given by Mr. Robert Porter in the Census Bulletin No. 12, 1890.

There is another method of forecasting the census, which depends upon reported estimates of the population in various centers. "The World Almanac," for example, secures the best available data from government and other officials, and each decade estimates the census which is to be taken. In January, 1900, this estimate was 79.4 millions, while the census enumeration showed 76.3 millions. This was about 4 per cent. too high. In January, 1910, the estimate is given as 92.3 millions. If this is reduced in this ratio, it gives a result of 88.8 millions for the year 1910.

In conclusion, it may be stated that the results of empirical formulæ, unlike those of the mathematical formulæ, are never perfectly reliable or correct. It is, therefore, impossible to predict the population for 1910 with any such degree of certainty as one can predict the free fall of a body in a given interval of time. It is to these empirical formulæ, however, that science owes much of its progress, and the governments of civilized countries are spending thousands of dollars in order to bring the constants in these various formulæ a little nearer the truth. In its application to the problem before us, it may be stated that if the population for 1910 shall be found to conform to the general trend of increase in the population since the first census was taken, we may feel certain that it will come out about 89.7 millions. If, on the other hand, it shall be found to conform more nearly to the growth made in the last few decades, it will be about 91.3 millions. Of course, there

is always the possibility that the case may be an abnormal one and that the growth of our country will be found to conform to no formula which represents its past growth. In such a case, all empirical methods are helpless. It should be added that the formulæ used in this article are anti-expansion formulæ—that is, they do not include the insular possessions of the United States.

PRESERVATION OF THE FISHERIES ON THE HIGH SEAS

By CHARLES HUGH STEVENSON, LL.M., D.C.L.
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THE fishery resources on the high seas can not be regulated and conserved by municipal or national laws, and the governments of the world are in a just sense the trustees for the management of this great wealth, this common field, where all reap and none sow, where all harvest and none plant.

It is to the common interest of all nations to prevent indiscriminate depletion of these resources. Useless destruction is a crime against posterity. Doubtless a century hence no policy of our great president will add more largely to his fame than his efforts toward preserving the natural resources, and no branch of these calls for more prompt international consideration than the resources of the high seas.

Upon the subject of the preservation of these resources so that their yield may continue undiminished, so much is appropriate to be said that one is lost in the abundance of it. The animal and vegetable products of the seas differ almost as widely in their characteristics and needs as those on land, and equally diversified and complicated are the problems concerning the most favorable conditions of their production and development.

Fortunately, the problem of sewage pollution, doubtless the greatest destructive factor in the inland and the coastal fisheries, has little or no existence in a consideration of the resources of the areas under consideration.

From the standpoint of protective needs, the fishery products of the high seas may be roughly divided into four general classes, viz.: (1) the migratory species, such as herring, mackerel, bluefish, etc.; (2) the bottom or ground species, such as cod, haddock, flounder and flatfish, which are less migratory in their habits and remain in the same general locality; (3) those products which are fixed to the bottom and are to some extent susceptible of ownership, as sponges, pearl oysters, etc.; and (4) the aquatic mammals.

As regards the migratory fishes, there is an increasing belief that serious impairment of these species is beyond our present demands on them, and that the destruction effected by man is but child's play compared with nature's work in that direction. Many states from time to time have enacted restrictive legislation with a view to preserving them, but estimation of the beneficial effect of these regulations is generally discredited.

Since this legislation interferes with the established uses and customs of the fishermen, the burden is upon those who advocate it to prove that the benefit will outweigh the inconvenience. Ever since the influential voice of Huxley was lifted in its defense, the policy of unrestricted capture of the migratory species has continued to grow, this view being strongly supported by many eminent authorities of the present day.

With respect to the bottom fishes, cod, haddock, flatfish, etc., our present knowledge of the remedial effects of fishery restriction is so slight as scarcely to furnish a satisfactory basis even for national waters, much less for complicated international restrictions.

For the purpose of determining the best regulations for preserving the fishery resources with the maximum extent of their utilization, it is not easy to exaggerate the importance of systematic research in marine biology and the effect of fishing operations. Excellent work of this nature has been done and is yet in progress in many countries where the fisheries are of great extent.

International restrictions have been of two general classes, the one for preserving the resources and the other for the maintenance of good order among the fishermen and for preventing the destruction of property. To the former class belong the Bering Sea fur seal regulations, and in some particulars the Anglo-French regulations of 1843; while all the remaining conventions and regulations, the North Sea Conventions of 1882 and 1891, the Anglo-Denmark Convention of 1901 and the Sub-marine Cable Convention of 1884 are of the second class. A review of the history of these regulations shows that the arrangement of joint action is a tedious and difficult matter and ratification of the convention is always uncertain. Indeed, except so far as concerns the police of the fisheries, it does not appear that great practical benefit has resulted from the regulations already enacted for the fisheries in the international waters.

For the preservation of the coastal fisheries by means of municipal regulations, as well as for the more important matters of national defense and safety, the opinion is growing that the three-mile limit of the territorial waters is too narrow and that it should be extended considerably beyond the present distance.

This limit had its origin in the range of cannon, which determined the distance over which a nation was able to exercise jurisdiction from the shore. Since the efficiency of cannon has greatly increased, and is now considerably more than three miles, it is urged that the width of the maritime belt should increase correspondingly. In recent years most of the writers on international law have expressed views favorable to this increase.

The extension of the marginal belt was discussed by the Institut

de Droit International at its meeting in Paris in 1904. The general opinion was that such an extension was desirable, and it was agreed without a dissenting vote to recommend an increase to six miles, after the proposal to extend it to ten miles had been rejected by twenty-five votes against ten.

However, in view of the approval which the three-mile margin has received in international conventions, legislative bodies and judicial tribunals, the indefiniteness of centuries ago has become the vested rights of to-day, the once plastic cement which the workmen molded has now become so set and solidified with the passage of time that it is useless to discuss an extension of the distance of exclusive jurisdiction without absolute international agreement.

It can not be denied that such an extension would be vigorously opposed by some influential interests. Doubtless one is safe in stating that the trawl fishermen of Great Britain, for instance, would unquestionably object to it, and for very practical reasons. Exclusive of the White Sea and the Baltic, the trawling area outside the three-mile limit of northern and western Europe approximates 450,000 square miles. An extension of the marginal belt to six miles would place 81,000 square miles of this area within the territorial jurisdiction of continental countries, and an extension four miles further would exclude British fishermen from 135,000 square miles of the best trawling grounds, an area nearly equal to that of the North Sea. As the British trawling fleet greatly exceeds that of all the continental countries, the fishermen of Great Britain would have much to lose and nothing to gain by the extension.

On this side of the Atlantic, acceptance of the extension would depend very largely on how it would affect the rights and treaty privileges of the United States along the shores of the British provinces, which probably more than any other factor has influenced the present firm position of this government respecting a marginal belt of a marine league only.

More important from an economic point of view than several miles increase in the width of the marine belt is a clear and unquestioned international recognition of vested rights in attempts to exploit and develop definite areas of ground under the high seas, as in the cultivation of sponges, corals, pearl oysters, etc. There is a distinction in law as well as in fact between such an industry and a fishery dependent on the pursuit of free swimming fish in the ocean. Oysters, sponges and the like represent a peculiar kind of property. They are not *ferœ naturæ,* as they do not stray nor do they require taming, hence ownership may be acquired in them.

It can not be affirmed that this extension of territorial jurisdiction to cultivated sea bottoms has ever been made the basis of any treaty

or agreement, or has even been the subject of diplomatic discussion. With the single exception of Vattel, the older writers on international law were silent on this matter, and even Vattel seems not to have clearly distinguished it from the exercise of jurisdiction over migratory fishes in the seas near the marginal belt, a doctrine which has long since been discredited.

Very natural was the silence of the older publicists on this subject, since there was no occasion for recognition of this view until a very recent period. The spirit of scientific investigation and of industrial development is everywhere, and in few directions have these made greater progress in the last score or two of years than in the possibilities of cultivating the sea bottoms. Millions of dollars' worth of oysters are now grown on areas which thirty years ago were barren wastes. Biologists are obtaining excellent results in sponge culture in the Gulf of Mexico, and are investigating coral growth in the Mediterranean. Careful observers are awakening to the possibilities of pearl culture, not simply to raise the mollusks which yield pearls fitfully and at rare intervals, but to insure and to increase the yield of pearls within these mollusks, and thus to obtain remunerative returns without the arduous toil and the element of hazard inseparable from pearling as now prosecuted.

And must the work of these investigators, must the enterprises which they stimulate, be restricted to the bounds of the marine league while the broad areas of shallow bays and gulfs remain barren? Must we plant and harvest but along the wave-washed shores of the maritime belt and leave the rich meadows of the sea bottoms to waste? Must the work be handicapped by the refusal of international law to concede to these enterprises the elements of ownership, which must be wholly lacking unless territorial jurisdiction apply to the areas which they exploit?

Numerous instances exist in which fisheries for pearl oysters, etc., prosecuted beyond the marginal belt, are the subject of fostering care on the part of a government or its people. By careful supervision as to close seasons, size limits, etc., and in some cases special preparation of the bottom and even removal of predaceous enemies, the output from these areas is conserved and increased. Instances of this kind, under state authority or recognition, may be regarded as an occupation of the bed of the sea, and territorial jurisdiction should rightly extend to them even though they be carried on beyond the marginal belt ordinarily recognized by international law. Even Grotius's *Mare liberum* is founded upon the old doctrine of Roman law that there can be no property in anything without occupation. And while the vagrant waters of the ocean can not be subjected and occupied, the sponge beds and pearl reefs can be even as the hills and the prairies.

This view is founded not only on justice, but likewise on necessity.

Man's eagerness has so nearly exhausted the easily exploited resources that fostering care is essential to the best development and use of the sea bottom. Left to the chance of nature and subject to despoilment by every one without hindrance, these areas would remain barren wastes. Law and government are for the benefit of humanity, not to foster waste. The aim of international law is the welfare and happiness of the general society of mankind, and this would not be promoted by a policy which would keep the sea bottoms forever unproductive. The reason for the freedom of the high seas is the freedom of intercourse and commerce between the states, the seas being the common highway; and a recognition of the occupancy by an individual nation of so much of the sea bottom as it may actually improve and develop does not impair the perfect freedom of navigation by vessels of all nations, as this occupancy is subordinate to the right of navigation and fishery and can not be exercised in derogation thereof.

Necessarily in the recognition of this extension of jurisdiction, the interests of the various states must be carefully guarded, and especially of those near the areas to be exploited. Within general limits, the right of exploitation and development must be reserved to the nation within whose sphere of influence the particular area is situated, for it would be manifestly unjust, indeed extremely unwise, to establish a principle by which a nation could appropriate to itself a resource off the shores of a less enterprising country. The privilege of exploiting the sea bottom in the whole of the Gulf of California, for instance, should undoubtedly rest with the Mexican people; Ceylon and British India should have control of that in the Gulf of Manar, and the riparian states should possess those in the Persian Gulf and the Red Sea.

However we may view the protective needs of the migratory and the bottom fishes, the situation is quite different with respect to the great marine vertebrates, the seals, walrus, manatees, sea otters and many species of whales. These animals are approaching practical exhaustion with great rapidity, and prompt action seems necessary if they are to be preserved from extinction.

This is not the language of exaggeration. Under the influence of the bounty of $25 which industrial use offers for the life of a fur seal, $300 for a sea otter and $8,000 for an arctic whale, these animals are passing away far more rapidly than is generally realized, the entire annual product of sea otters throughout the world now approximating only 200 and of arctic whales less than 100 each year. The timid whalebone whales have been swept from the navigable seas and are nowhere to be found except in the most remote ice fields of the frigid zones.

The walrus are almost exterminated in the seas north of Europe; and where they were formerly so plentiful in Bering Sea, they are to be

found only in one small herd, which hauls out in the spring and fall on the islets off Port Heiden, on the Alaska Peninsula.

It is shocking to contemplate the indifference with which the civilized world has witnessed, nay, not only witnessed but encouraged the slaughter, almost to the point of extinction, of highly organized animals evidencing traits of affection and devotion which would do honor to human beings. Everywhere, in every sea, it is the same story, destroy! destroy! destroy! What more pathetic sight in the whole range of man's ruthless destruction than the thousands of nursing fur seals starving and dead on the shores of the Pacific islands as a result of the inhuman butchery of their nurture-seeking mothers in the waters of Bering Sea and the North Pacific. At the present rate of decrease the day is not far distant when they will have become as extinct as the buffalo of the American prairies.

Let it not be understood that our sympathy for the highly organized creatures of the sea would withhold them from industrial use. The slaughter of animals under proper safeguards, whether they be in the seas or under domestic care, does not in itself constitute needless cruelty, for the end of every individual, beast or human, is pathetic, whether it result from sudden accident or through the waste of years. When this slaughter is so conducted that it is conservative utilization, with due care for the welfare and perpetuation of the species as a whole, it is but the most intelligent application of nature's wisest law of the survival of the fittest. The preservation which we would extend to these animals is largely for the purpose of their greater use. We would surround them with such protection and take them only under such conditions as would tend to increase their numbers and thus make them of far greater value to the hardy fishermen whose industry has won renown in all ages. It is hoped that the wide public interest attracted to the preservation of our natural resources will result in preventing the now imminent extermination of these species, whose zoologic and philosophic worth far exceeds their economic value.

It is beyond the limits of this paper to outline the proper direction of the efforts to preserve these resources. But in view of the fact that the fisheries on the high seas represent the greatest economic resource which the nations of the world hold in common for their joint use, it seems that there might be wisdom in a general treaty or international union for their consideration. Already there are several treaties of this nature with special international offices for the purpose of satisfying economic and other nonpolitical interests, such as the Universal Postal Union, established in 1874, the Union for the Protection of Industrial Property in 1883, and the Union for the Protection of Works of Literature and Art in 1886. More closely allied to our subject is the convention in behalf of the preservation of wild animals,

birds and fish in Africa, which was signed in London on May 19, 1900, by France, Germany, Great Britain, Italy, Portugal, Spain and the Kongo Free State.

And at this time when the preservation of natural resources is receiving so much attention, what subject more worthy of consideration than the economic conservation of the resources of the seas? A brotherhood of great nations arranging not the partition of nature's inheritance among themselves for speedy waste and despoilment, but the preservation of that inheritance for beneficial use in common by all the people of the earth; each to draw upon that storehouse of wealth only in accordance with the common welfare of all, for the sustenance of its citizens, for the comfort of its people and for the advancement of civilization throughout the world.

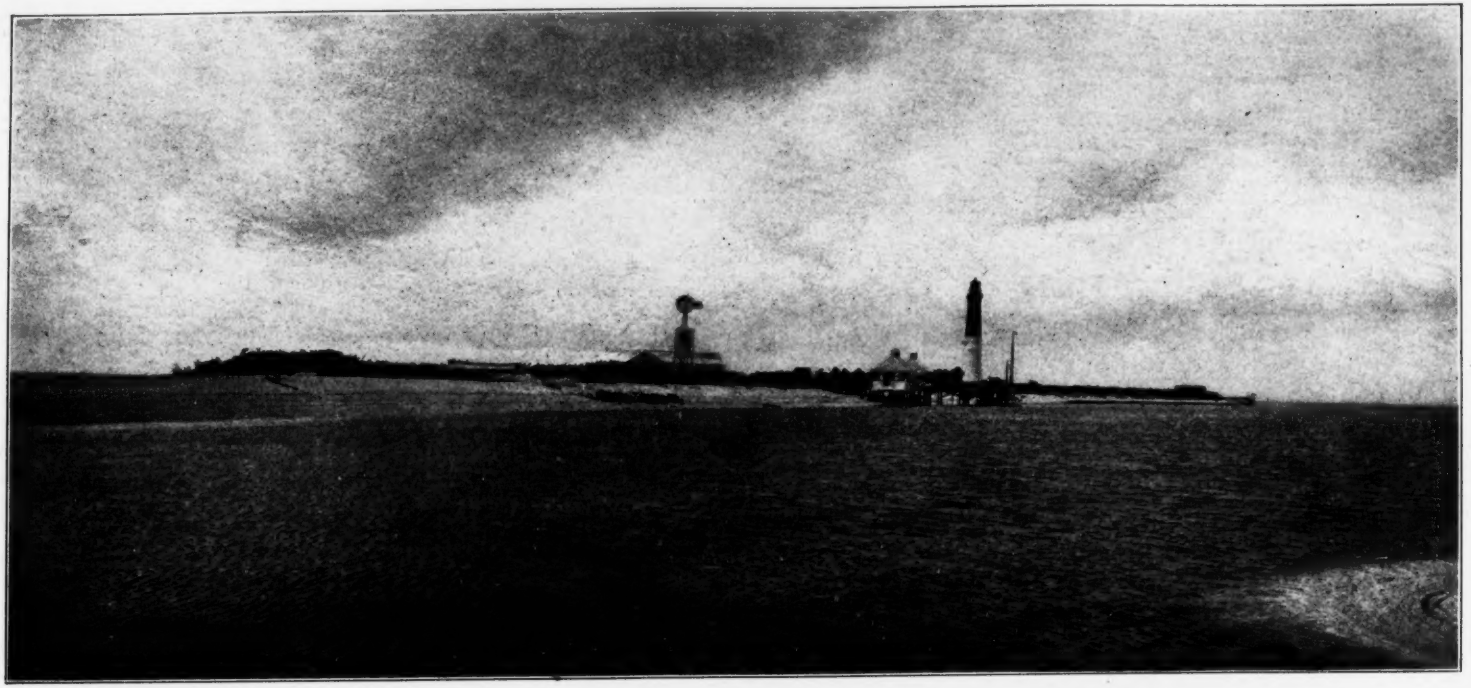


FIG. 1. GENERAL VIEW OF THE TORTUGAS LABORATORY FROM THE NORTHWEST IN 1906.

THE RESEARCH WORK OF THE TORTUGAS LABORATORY

By Dr. ALFRED GOLDSBOROUGH MAYER

MARINE BIOLOGICAL STATION OF THE CARNEGIE INSTITUTION AT TORTUGAS, FLORIDA

NEARLY seventy miles west of Key West, out in the Gulf of Mexico and in the most isolated situation occupied by any islands off our coast, lie the seven small keys of the Tortugas. Between them and the Cuban coast flows the great current of the Gulf Stream, and to the eastward of them lie forty miles of open water beyond which are their nearest neighbors, the Marquesas Keys of Florida. The Tortugas are the most westerly and southerly and the newest geologically of all those coral and limestone islets which are strung chain-like one after another in a long graceful sweeping curve from Cape Florida southward and always westward to end in the Tortugas.

The Tortugas Keys are low, being only as high as the winds and waves can toss the shifting sea-sands which compose them, for they consist entirely of wave-broken fragments of shells with here and there the stony skeleton of a seaweed, echinoderm or dead coral. Every particle composing them was once part of a living creature in the ocean which surrounds them, and thus the islands are but the dead remains of living things that were. A stunted twisted growth of bay cedars and cactus clings to their sandy soil and defies the salt spray which in time of storm drives completely over the islands. Almost every plant surviving upon the Tortugas is tough-leaved and juicy inwardly, or it sends roots far down through the sand to the salt water, for the rain serves but poorly to moisten the loose sandy soil through which it filters rapidly. The Tortugas Keys constitute the rim of an irregular atoll enclosing a lagoon with many a coral patch rising ominously out of deep blue water to within a few feet of the surface. In the old days tradition says that its harbor was the retreat of many a pirate safely anchored in the midst of the maze of its coral reefs.

Yet the islands, although remote, are not desolate to the naturalist, for all around them lies the deep blue of the tropical ocean, its ripples flashing merrily in the brilliant sun, and looking downward through the crystal depths one floats above the richest coral reefs of the Florida region. No butterflies of an East Indian jungle outrival the brilliant fish which glide languidly in and out among the purple sea-fans bending majestically to the surging sea. Hundreds of creatures find their homes among the caverns of the coral reef, or under the great carpets of rich yellow and olive sea-anemones which overgrow the naked rock

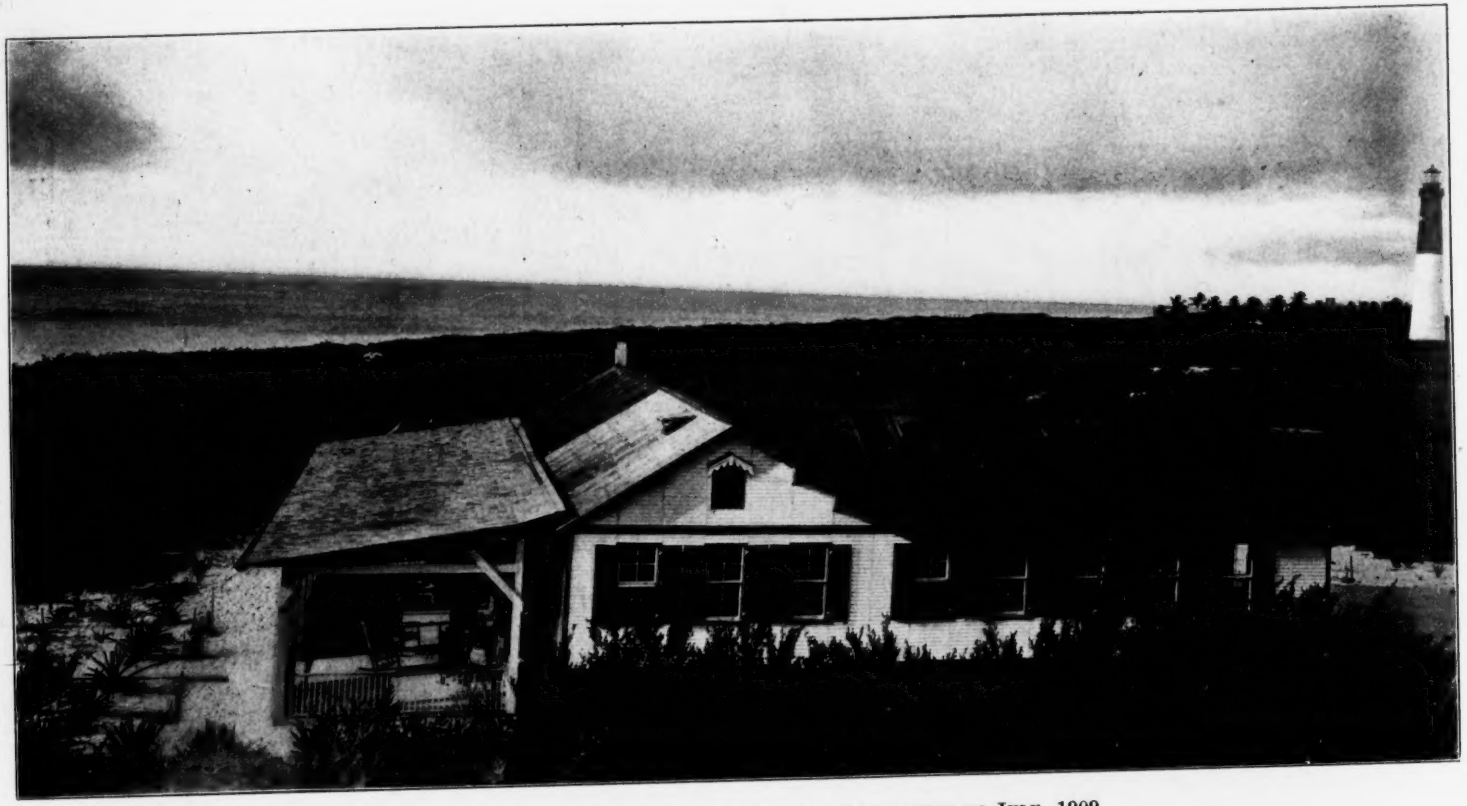


FIG. 2. THE MAIN BUILDING OF THE TORTUGAS LABORATORY IN JULY, 1909.

that once was living coral; and the Gulf Stream, that greatest carrier of floating life, flows close to the Tortugas, and the southerly and easterly winds of the summer months constantly drive its dark blue waters upon the islands.

It is on account of these things that the Carnegie Institution of Washington, seeking always to promote research in fields that others can not, or dare not, venture to explore, has established a marine laboratory upon Loggerhead Key, Tortugas. The station is still young, its first season being that of 1905.

The era of finding and naming of animals which had its dawn with Linnæus and its noonday of splendor with the great French naturalists has waned into its dignified decline. Not that systematic zoology will not accomplish much in the future, but the days of its great achievement are in the past.

Therein, indeed, lies the opportunity of the Tortugas laboratory, for a new science has arisen phœnix-like above the ashes of the old. Modern biology is now but little concerned with the naming of dead things, but the study of the living has become of paramount importance. All problems necessitating the study of living animals have been neglected in the tropics, yet there in the pure water of the Gulf Stream one may conduct such experiments with extraordinary success. It is through the study of living animals that science has already discovered truths of incalculable benefit—the control of malaria, yellow fever, and the hook-worm—but a mere beginning has been made in this new science, and, if unrestricted by ill-considered legislation, its future promises far more than its brief past has given us.

As Franklin said when asked the purport of the study of so trivial a set of phenomena as those of frictional electricity—"Of what use is a baby? It may become a man." Who could predict that a reflection of the sun from the windows of the Luxembourg would reveal to Malus the secret of polarized light, and lead ultimately to the most accurate analysis of sugars. It is a reflection upon our lack of confidence that in this age one must still plead for the cause of pure science, for everywhere about us we find practical applications rendered possible only through the previous discovery of their underlying principles by students whose inducement to labor was their love of science, not the hope of financial gain. Thus it was that Henry paved the way for Morse's telegraph, Faraday's classic studies rendered possible the dynamo and electric motor, and the researches of Hertz found their practical application in the development of wireless telegraphy.

Fifty years ago Darwin changed biology into a philosophical science, but it is only recently that it has exhibited decisive evidence of passing out of the qualitative into the quantitative stage of its development.

Thus it is that in these days a marine laboratory is dependent not

FIG. 3. COCOANUT GROVE NEAR THE TORTUGAS LABORATORY.

mainly upon a rich and varied fauna, but upon the presence of animals which may be found in abundance in its immediate neighborhood, and which provide favorable subjects for experimental studies.

When we contemplate the vast numbers of so-called researches published every year, it becomes evident that science will be advanced more surely by improving the quality of these papers than by increasing their bulk. For a generation the civilized nations of the world have at great expense maintained experiment stations to improve the breed of plants and animals useful to man, but nearly all of them have labored under the false impression that researches can be produced at stated intervals. Much of that freedom so essential for research was sacrificed to the production of bulky annual reports restricted to the accounts of "purely practical" studies. It was not an accident that Mendel, laboring obscurely in his cloister garden and with no thought save but for nature and her ways, discovered the law of heredity which all the experiment stations in the world failed to find.

Anton Dohrn did well for science when he gave his fortune to build the Naples Laboratory, but he did far better when he granted to those who labored there unlimited time and boundless freedom in thought and action, and his confidence was rewarded, for at Naples have been produced many of the greatest papers known to biological science.

Concentrating its efforts solely upon research, the Tortugas is in no sense the rival of other educational institutions, its simple object being to supplement and extend the work which others are attempting,

or to render possible the prosecution of researches which no other institutions can undertake. Indeed, the success of any research laboratory must depend upon the efficiency of the training which its investigators have received at institutions of both instruction and research, such as the laboratories at Woods Hole, Cold Spring Harbor, Bermuda, South Harpswell and St. Andrews.

At Tortugas some of the ablest investigators of our country have been directing their attention not only to the systematic study of the rich reef fauna of the region, but mainly to problems in physiology, ecology, regeneration and embryology. We shall have space for a review of the results of a few only of these studies, selecting such as may be of the widest general interest.

Throughout the autumn and winter one of the most desolate of the Tortugas Islands is the small uninhabited Bird Key; but suddenly on a day late in April or early in May a cloud of sea-gulls gathers from far and near, and soon more than 25,000 birds are screaming over the island, struggling for nesting space.

Undeterred by the roasting heat of desert sands, the air above which rises to at least 120° F. on every sunny summer's day, or by the ceaseless shrieks of sea-gulls, Professor Watson, of Johns Hopkins University, lived nearly three months upon Bird Key. He reared the young birds and found that they could learn their way through a maze to their food. The adults could also learn to overcome obstacles in seeking to sit upon the eggs. The noddy gull builds its nest in bushes and while

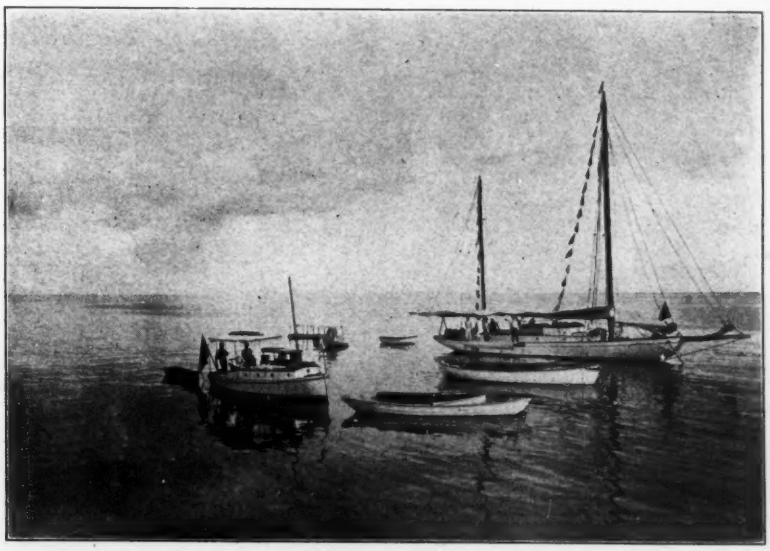


FIG. 4. THE FLEET OF THE TORTUGAS LABORATORY.
The *Physalia*, *Sea Horse* and launches.

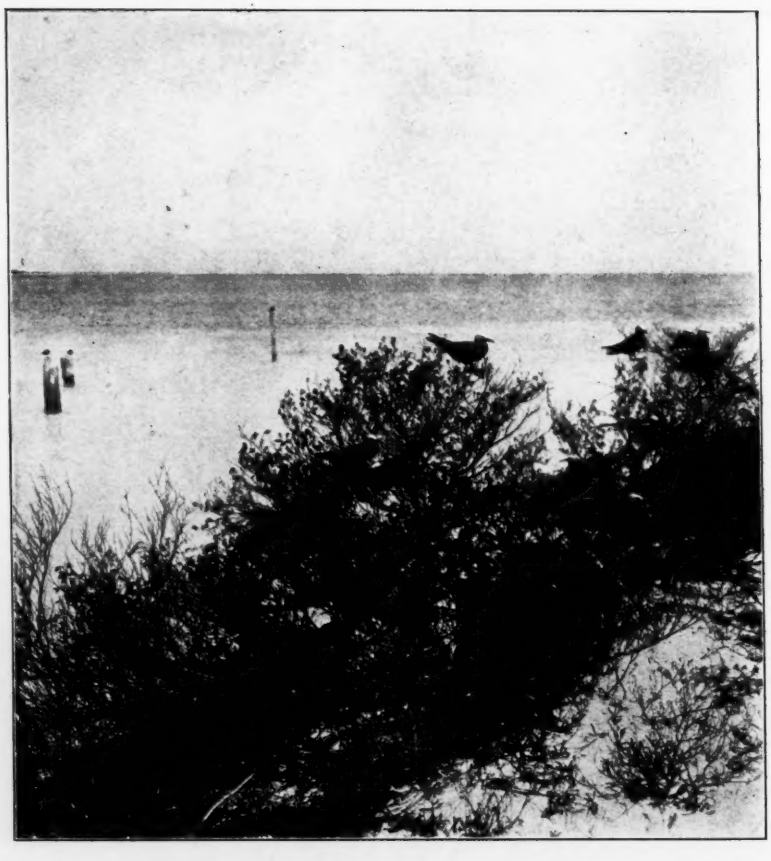


FIG. 5. NODDY GULLS NESTING ON BIRD KEY, TORTUGAS.

so doing is quite shy, but if an egg be placed in the nest the mere sight of it causes the bird to lose all shyness, and it sits upon the egg as if it were its own. Both male and female cooperate to build the nest, but the male alone procures food for both during this period, the female constantly guarding the nest. After the egg is laid, both male and female fly away to fish and take their turns in brooding the egg at intervals of about two hours. The egg hatches after 32 to 35 days. But the noddy gull does not recognize its own egg, but will readily incubate the egg of the sooty tern or any object colored or uncolored bearing more or less resemblance to an egg. It recognizes the locality of its nest, however, and returns to the old locality if the nest be moved, but it will accept an artificial nest placed in the old nest locality without hesitation. Dyeing one of the mates in strange colors causes the undyed bird to attack it, and indeed all other birds upon the island displayed excitement at the appearance of a dyed bird.

The sooty tern nests upon the ground, and recognizes the exact lo-

cality of its nest, if, however, the nest be raised vertically, the bird, but little disturbed, alights upon it, then if after an interval it be lowered, the bird attempts to alight in the air above the nest in the place where the nest was formerly. A slight *horizontal* movement of the nest causes great confusion in the bird.

Professor Watson caused adult birds to be taken from Bird Key to Havana, 92 miles; to Key West, 66 miles, and to Cape Hatteras 850 miles from Bird Key. Birds liberated at these places returned in a very short time to their nests on Bird Key. The sooty terns returned from Cape Hatteras in five days, and as they probably flew along shore and not by the straight-line route, they must have flown at least 1,081 miles. This is a most striking experiment, for Cape Hatteras is far to the northward of the northern limit of the geographical range of these birds.

Another Tortugas research was that of Professor Reighard, of the University of Michigan, who worked upon the subject of warning coloration.

For a long time Darwin was puzzled by the fact that many animals are conspicuously colored and yet their habits are such that they openly display themselves to the view of all possible enemies. Why, then, were they not exterminated? That brilliant yet modest man, Alfred Russel Wallace, came forward with an ingenious hypothesis, now well known as the theory of warning coloration. He assumed that such con-

FIG. 6. A NODDY GULL UPON ITS NEST, BIRD KEY, TORTUGAS.

FIG. 7. GROUP ACTIVITY OF SOOTY TERNS.

spicuous animals possessed poisonous or disagreeable qualities which rendered them unpalatable, so that their enemies soon learned to recognize them as uneatable, and thus the more conspicuous their appearance, the more surely were they protected.

It has been assumed that the beautifully colored fish which swim so unconcernedly and slowly in and out among the caverns of the coral reefs were good examples of warning coloration, for over the sandy

FIG. 8. GROUPS OF NESTING SOOTY TERNS.

bottom around the corals swims the gray snapper, the commonest predaceous fish of the reefs. Yet these gray snappers are not seen to attempt to devour the reef fishes. Professor Reighard found, however, that when he captured these beautiful reef fish and threw them in among the gray snappers far from the reefs they were greedily devoured without a moment's hesitation. It became evident that the gray snapper could not capture the brilliant little fishes as long as they enjoyed the protection afforded by the stings of the coral polyps, or remained near the entrances to the intricate caverns of the reefs. Hence these fishes are not warningly colored, and Wallace's hypothesis does not apply to them.

Nevertheless, Professor Reighard found that the gray snapper *could* distinguish colors, and that it could be *taught* to associate a brilliant color with an unpleasant taste.

In order to prove this, he made use of the little silvery sardine (*Atherina*) which swarms in thousands over the shallows of the reefs, and whose only office in life seems to be to supply food for all larger fishes. Reighard dyed these silvery fish a brilliant carmine red and the gray snappers devoured them without hesitation. Then, however, the tentacles of a medusa were placed in the mouths of the red-colored sardines and the gray snappers soon learned after a brief experience with the stings to avoid them; and they *remembered* to avoid red-colored sardines after an interval of twenty days had elapsed since they had last seen them, although these later red fish had no medusa tentacles in their mouths. Thus he created a warning coloration; something nature herself had not done.

Professor Reighard's experiments are by far the most convincing that have ever been carried out upon the subject of warning coloration, being performed in surroundings natural to the animals themselves. He concludes that the conspicuous coloration of coral-reef fishes is is not for warning enemies, and is the result of race tendency unchecked by selection.

Another research of interest was that of Dr. Stockard, of the Cornell Medical College, upon the habits of the walking-stick insect, *Aplopus*, which lives upon the bay cedar (*Suriana*) bushes at Tortugas and bears an extraordinary resemblance to a stick of the bush itself, while its eggs resemble the seeds of the same bush. Professor Stockard finds that the habits of the insect accord perfectly with and enhance the value of its protective coloration. The insect is active only at night, or in darkness, and in daylight they may be piled one on top of another, remaining motionless as real sticks in any attitude, but if they then be placed in the dark they immediately scramble off in all directions.

In another research Dr. Stockard studied the regeneration of the claws of the snapping-shrimp *Alpheus* which lives within the cavities

of sponges. This little lobster-like animal has one very large claw and one small one, and when captured it snaps the nippers of the large claw, producing a sound resembling the sudden cracking of thick glass, so that one imagines that the aquarium has broken. It is well known

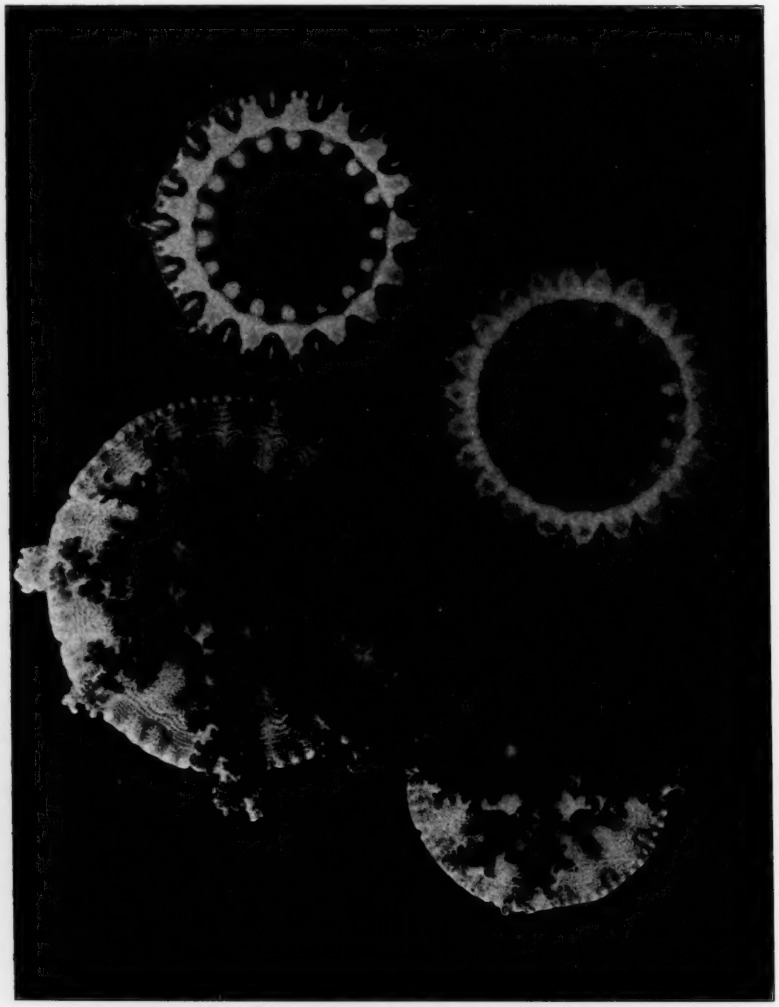


FIG. 9. *Cassiopea xamachana*, THE JELLYFISH OF THE MOAT OF FORT JEFFERSON, TORTUGAS.

from the work of Prizbram that if the large claw of *Alpheus* be cut off the small claw changes to a large one at the next molt.

Dr. Stockard finds, however, that if the large claw be removed and at the same time all legs of the *opposite* side of the body *except* the small claw be cut off, the small claw does not change into a large one

and the animal acquires two equally developed small claws at the next molt. Thus a tendency toward a reversal is checked.

In another research, Dr. Stockard made the interesting observation that when a piece of a jellyfish (*Cassiopea*) is cut away and the animal starved a new piece regenerates, even though the old part of the body shrinks in size to provide it nutriment. Cancers also grow in this manner at the expense of the surrounding tissues, and thus there appears to be an analogy between the mode of growth of cancer and regeneration. Possibly, then, if we could control regeneration some similar process might be found effective to check the growth of cancer.

As is now well known to naturalists, Tower has succeeded through the influence of heat and moisture in producing a new sort of beetle which breeds true as would a newly arisen species. MacDougal has also succeeded through chemical means in effecting the same result with plants. Recently, at Tortugas, Professor Tennent, of Bryn Mawr, produced hybrids by reciprocal crosses between *Hipponoë* and *Toxopneustes,* two common sea-urchins of the reefs; and he discovered the interesting fact that if the sea-water be normal or rendered alkaline the larvæ resemble the *Hipponœ* parent, but if the sea-water be treated with an acid so as to reduce its alkalinity the larvæ resembled their *Toxopneustes* parent. He could then by changing the external conditions produce larvæ resembling either parent he choose, and thus alter the dominance of either parent at will.

No one knew what caused the newly hatched young of the great sea-turtles to crawl toward the ocean as soon as they had dug their way upward out of the sand within which their eggs are laid, but Dr. Davenport Hooker, of Yale, found that the young turtle is attracted toward the ocean by the blue color of the water. If it sees the ocean through red, yellow or green glass it does not crawl toward it, but if a piece of blue glass, or even blue paper, be placed anywhere within range of its vision the turtle at once scuttles toward it with great excitement.

If one goes out upon the ocean before sunrise on the morning of a day within three days of the time of the last quarter of the July moon, the surface will be found to be covered with actively wriggling worms, about six inches long, swimming in all directions. These are the posterior ends of the Atlantic palolo worm (*Eunice fucata*) which breaks off from the head end of the animal and swims upward from the crevices of the coral reef, to take part in the breeding swarm. Professor Aaron L. Treadwell, of Vassar College, is now studying this phenomenon, and he has discovered that if the rocks containing the worms be placed in a dark chamber upon the day preceding the night of the swarm the worms may still swarm. Hence, contrary to Mayer's supposition, the presence of moonlight is not necessary for the swarming reaction. Previous studies at Tortugas have shown that the

FIG. 10. THE ATLANTIC PALOLO WORM. *Eunice fucata.*

swarming is not due to tidal influences, and now the great question is —what *does* cause this remarkable response, for it appears to be some form of energy to which we are ourselves not sensitive.

Dr. T. Wayland Vaughan, of Washington, finds that the line of the Florida Keys from Soldier's Key to the southeastern corner of Big Pine Key is composed of elevated coral-reef rock. The northern end of Soldier's Key and all keys to the northward of it are composed of quartz-bearing sands mingled with broken shells. The keys from Key West to Big Pine Key, with the exception of the southeastern corner of the latter, are composed of limestone mud which long ago was elevated above the sea and changed into rock, so that now one sees a net-work of old mud-cracks in the rocky floor of the pine forest. On the continental side of the line of coral-reef keys and extending transversely to them are long shoals formed by the settling of lime mud in the slack water between the currents which flow in and out with the tides through openings between keys. These shoals become covered with mangroves, and thus finally elevated above the surface of the sea. There are many other interesting geological observations made by Dr. Vaughan which limitations of space prevent us from reviewing.

In addition to his studies of the geology of the reefs, he is making

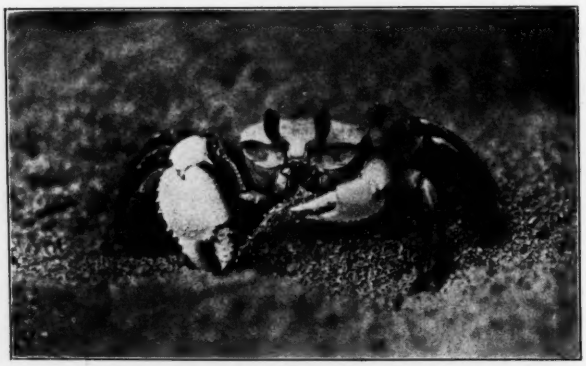


FIG. 11. THE GHOST CRAB, *Ocypoda arenaria.* Photographed by Dr. R. P. Cowles.

the most accurate and extensive investigation of the associations, habits, rate of growth and constitution of corals ever attempted by any naturalist. He is rearing corals from the free-swimming larva, and observing their rate of growth as well as studying the growth-rate of many coral beads found living upon the reefs or in the moat of Fort Jefferson. Years must elapse before the results of these studies will be ready for publication, but he has already discovered that under favorable conditions the rate of growth of corals is surprisingly rapid, and that the free-swimming stage of the planula lasts long enough for corals to be drifted fully 800 miles by the Gulf Stream.

Professor Edwin G. Conklin, of Princeton, finds that the egg of the scyphomedusa *Linerges* consists of an outer layer of clear protoplasm, an intermediate shell of densely packed yolk spherules and a central sphere of dissolved yolk. The outer layer of the egg forms the peripheral layer of the gastrula and blastula, and gives rise to the cilia of the ectoderm. The middle layer constitutes the principal part of all of the cells of the body, while the central yolk serves for nourishment. Thus animals so low as the jellyfishes show the beginning of that differentiation of organ-forming substances in the egg which Professor Conklin discovered was so characteristic of the eggs of higher forms. He also finds that the gastrula larva in this medusa may be formed either by invagination or by unipolar ingression, thus showing the intimate relationship between these apparently distinct processes.

Dr. R. P. Cowles, of Johns Hopkins, carried out an extensive series of observations upon the habits and reactions of the ghost crab *Ocypoda arenaria,* which lives upon the sandy beaches of the Tortugas. It will be impossible to do more than present a few of his most important results. He finds that this crab can not detect color, but is sensitive to large differences in the intensity of light, and it readily perceives a moving object. The color pattern of the crab changes under different conditions of light and temperature, becoming dark and mottled in dull light and low temperature. It can not detect sound waves traveling through air, but its so-called "auditory organs" are actually organs of equilibration. The crab has memory, is able to profit by experience and can form habits.

Dr. Frank M. Chapman, of the American Museum of Natural History, discovered that the booby, *Sula fiba,* which nests upon Cay Verde, Bahamas, between February and April, lays two eggs but rears only one young bird. His observations and collections upon Cay Verde has led to the construction of a very attractive group in the American Museum of Natural History in New York illustrating the nesting habits of the frigate-bird and the booby.

Pleasurable as the task would be, limitations of space prohibit my reviewing the results of the studies of Messrs. Brooks, Hartmeyer,

THE TORTUGAS LABORATORY FROM THE TOP OF THE LIGHTHOUSE.

Harvey, Jordan, Kellner, Linton, McClendon, Osburn, Perkins and Pratt, all of whom have produced careful and important work.

The laboratory is very young; it can not yet claim to have been a success, for despite the fact that some of our ablest workers have seen fit to strive in its interests, the time which has elapsed since its foundation is too short to enable us to do more than to assert that with such generous self-sacrificing devotion to its cause as has been shown by those who have honored it by their labors, success will come with the years that lie before it.

THE PROGRESS OF SCIENCE

INCORPORATED CHARITIES

THE bill before the congress to incorporate the Rockefeller Foundation opens up many social, educational and scientific problems. Its objects are stated to be "to promote the well-being and advance the civilization of the peoples of the United States and its territories and possessions, and of foreign lands, in the acquisition and dissemination of knowledge, in the prevention of suffering and in the promotion of any and all the elements of human progress." The bill names as incorporators of the foundation John D. Rockefeller, John D. Rockefeller, Jr., Fred T. Gates, Starr J. Murphy and Charles O. Heydt. The amount of the endowment is not known, but it is assumed that it will be very large, as Mr. Rockefeller has already given fifty-three million dollars to one board of much narrower scope.

There should be nothing but sincere appreciation of Mr. Rockefeller's generosity and public spirit. It is quite absurd to fancy that he has sinister motives or any other wish than to do good with his wealth. This would be the right attitude even if the money had been obtained by improper methods. But there are probably not many men of affairs in America whose transactions if so fully known would be less open to blame. Secret rebates and harsh competition are the charges. There are not many clergymen or statesmen who refuse to accept rebates from the railways and competition to the limit of the law is the common method of business. As a matter of fact, there has never been a man of business who has done so much to abolish competition as Mr. Rockefeller, who will probably be looked upon hereafter as the principal promoter of socialism.

Mr. Rockefeller's corporation for charity and public service is less original and less imposing than his business corporation. It is insignificant beside the Roman Catholic Church in the middle ages or beside what is now being done by every state for charity and education. Mr. Rockefeller's wealth would scarcely support the public schools of the country for a single year. None the less a corporation of this kind will for a time have considerable power and there is some reason to fear that it will not be wholly beneficial.

Society is concerned more about the consumption of wealth than about its ownership, so long as the ownership is not used outside the ordinary methods of business. It is obvious that wealth is consumed more profitably in promoting the acquisition and dissemination of knowledge and the prevention of suffering than along the paths which lead to the divorce courts. But it is not certain that it is better to divert capital from business enterprises, tie it up in real estate and lands exempted from taxation, and use the income permanently for charity. What may happen is shown by the Roman Catholic Church, which in the middle ages acquired nalf the wealth of the nations and instead of contributing to the advancement of civilization became on the whole a barrier to progress.

Other corporations for public and charitable purposes are controlled by a board representing a church, the educational interests of a community, or the like, and have some definite object. This new corporation represents and is controlled by the Rockefeller family and its scope is unlimited. An emergency fund for the promotion of civilization appeals to the imagination, but it will not be easy to administer it. We have had recently experience of two such funds with more limited

scope—the General Education Board and the Carnegie Institution of Washington, to which, respectively, Mr. Rockefeller has given $53,000,000 and Mr. Carnegie, $12,000,000.

The General Education Board does not even make public its activities or its accounts. It has concerned itself with agricultural education in the south, but its income has been spent in the main in contributing to the funds of colleges and universities on the condition that four times as much should be collected from other sources. It is not clear how the foundation is more useful than if the whole capital were at once distributed among the colleges and universities of the country in proportion to their existing endowments. The Carnegie Institution was established as an emergency fund for scientific research, but it was not found feasible to conduct it on these lines, and it now administers certain research institutions. Here again there seems to be no advantage in maintaining at Washington an expensive administrative office. It would be better to divide the capital among the observatories and laboratories and let them develop as they can.

Mr. Rockefeller's most useful and important benefactions are the University of Chicago and the Rockefeller Institute for Medical Research. It would probably be of greatest benefit for society if he should use his fortune to establish three or four great universities with their research institutions, libraries, museums, theaters and hospitals. Chicago could be further endowed and universities established in the city of Washington, Texas and Oregon, or, if it were preferred to make the influence world wide, the universities could be in Washington, South America, China and Russia.

THE CARNEGIE FOUNDATION FOR THE ADVANCEMENT OF TEACHING

THE benefits and dangers of a centralized endowment for public purposes are well shown by the Carnegie Foundation, the fourth annual report of whose president has recently been issued. On April 16, 1905, Mr. Andrew Carnegie addressed a letter to twenty-two college presidents and three business men whom he had selected as trustees, transferring to them $10,000,000 in bonds of the U. S. Steel Corporation "to provide retiring pensions for the teachers of universities, colleges and technical schools in our country, Canada and Newfoundland." He says that "expert calculation shows that the revenue will be ample for the purpose" and "I have reached the conclusion that the least rewarded of all the professions is that of the teacher in our higher educational institutions."

These college presidents drew up an act of incorporation and rules which in the main would distribute the income among certain institutions for their advantage rather than for the benefit of the individual professors. Cornell and Williams have continued to pay the pensions for which they had contracted, so their professors receive double pensions, but other institutions having pension systems have withdrawn them and diverted the money to other purposes. Professors in colleges accepted by the foundation and not having pension systems may benefit, as they receive annuities which they did not earn; but the salaries will soon be adjusted with a view to the pensions, and the income of the foundation will be distributed among certain institutions having pension systems, not at all to individual professors.

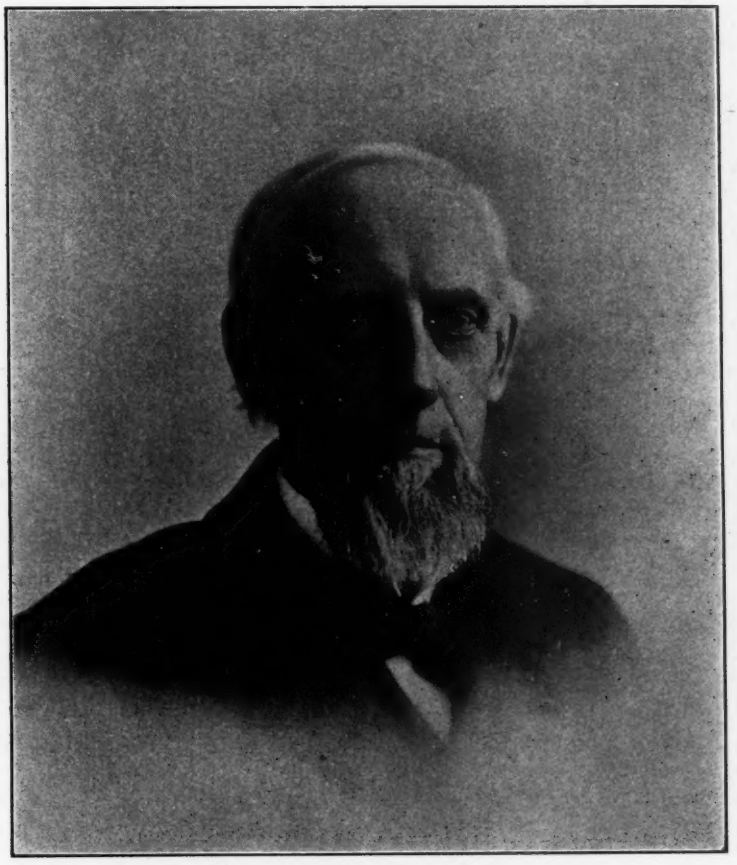
The professors benefit only if a pension system is advantageous to them. Any one can purchase an annuity, and it is doubtful whether the enforced purchase of annuities by professors combined with dismissal from their work is of benefit to them. A centralized system works especially to the disadvantage of the individual professor. If an institution had to pay a pension from its own funds, it would be much more conservative in retiring

a professor who is willing and competent to stay in service. To benefit the professor, his salary should be paid for life and he should render such services as he can to advantage. The dismissal of professors on pensions throughout the country against their will may have the unfortunate effect of breaking down the permanent tenure of the professor's office, which has done more than anything else to give it dignity and to attract to it able men willing to serve for small salaries.

The act of incorporation of the Carnegie Foundation provided for two kinds of retiring allowances: (1) for long and meritorious service, and (2) for old age, disability or other sufficient reason. At the last meeting of the trustees, the retiring allowances for length of service were withdrawn, not only for the future but also retroactively from those to whom they had been promised. Dr. Pritchett, the president, states that the ground for withdrawal was that the rule worked badly; Dr. Jordan, one of the trustees, states that it was financially impossible to carry it out. Both results might have been foreseen, but neither seems to justify the foundation in breaking its engagements. The editor of the New York *Evening Post* does not hesitate to charge "a misty notion of the nature of moral obligations" and a violation of "the ordinary standards of honorable conduct between man and man."

The foundation supplies an additional income to a number of colleges and universities; but this appears to be the end of its usefulness. The attempt of an energetic president to lord it over the educational development of the country has done some temporary harm; but the money by which he can purchase submission will soon be exhausted. It has been a sorry sight to see institutions raising standards which they can not and should not maintain, freeing themselves nominally from denominational control—one has offered to establish an undenominational holding company—and most of

This photograph, showing a part of Harvard University in 1857 or 1858, is contributed to the *Harvard Graduates' Magazine* by Professor F. W. Putnam. The small square building of wood on the right of the church is the Agassiz Museum. Massachusetts Hall and Harvard Hall are shown on the right. The Agassiz Museum Building was erected in 1850. After the first section of the present Museum of Comparative Zoology was built, in 1859–60, the old Museum Building was moved to the site now occupied by the Peabody Museum. It was remodeled for living-rooms for Agassiz's students and assistants.



AMOS EMERSON DOLBEAR.

all to watch the great state universities begging the favor of a private corporation. Thirty-two state legislatures have approved the request for money, and the foundation finds that four of the universities are worthy, while the others—institutions such as California and Illinois—must be further investigated. The president tells the governor of Ohio how the universities of that great state should be administered; he says that "in nearly every state" there is "educational demoralization."

In his last report Dr. Pritchett makes all kinds of recommendations. Some are in themselves good and some bad, but all are bad in so far as they come from that source, for there is an implicit threat everywhere that institutions must do as they are told or they will not receive Carnegie money. The best thing that could happen would be for the foundation to retire its president with a liberal pension to write about education over his own signature, and then, as the Peabody Fund has wisely done, to dissolve and distribute its funds among our colleges.

AMOS EMERSON DOLBEAR

IN the death of Dr. Dolbear, for thirty-six years professor of physics and astronomy at Tufts College, America loses a man of science of a type that is now becoming rare. Born in New England in 1837, and left early an orphan child, he worked on a farm and at other odd jobs, attending the district school when he could. He became a machinist, had various adventures, and when twenty-six entered

what is now the Ohio Wesleyan University. He taught natural history and the physical sciences in western institutions until called to Tufts College in 1874. He was early an inventor and later made inventions which led him to believe that had anticipated both the telephone and wireless telegraphy. He was, however, unsuccessful in his suit against the Bell Telephone Company. But Dr. Dolbear did not confine himself to inventions; he did experimental work in various directions, wrote text-books and made addresses, and in his last work, entitled "Matter, Ether and Motion," discussed the fundamental principles of his science. Dr. Dolbear, in whose personality were commingled some of the traits of the scholar, the clergyman, the mechanic and the farmer, won the affectionate regard of all who were associated with him.

SCIENTIFIC ITEMS

WE record with regret the deaths of Dr. Charles R. Barnes, professor of plant physiology at the University of Chicago; Dr. Henry Byron Newson, professor of mathematics in the University of Kansas; Professor J. Edmund Wright, associate professor of mathematics in Bryn Mawr College; Dr. J. A. Bergström, professor of pedagogy in Sanford University, and Dr. Charles F. Wheeler, botanical expert in the Department of Agriculture.

LORD RAYLEIGH has been elected a foreign associate of the Paris Academy of Sciences in succession to the late Simon Newcomb.—The Edison medal of the American Institute of Electrical Engineers has been presented to Professor Elihu Thomson.—Dr. Hugo Münsterberg, professor of psychology at Harvard University, has been appointed exchange professor to lecture at Berlin in 1910–11.—Dr. S. Weir Mitchell celebrated his eightieth birthday on February 15. On the following day he gave a lecture before the College of Physicians of Philadelphia on "William Harvey, the Discoverer of the Circulation of the Blood."—Sir William Huggins, F.R.S., the eminent astronomer, celebrated his eighty-sixth birthday on February 7 at his residence at Tulsehill.

FOR the meeting of the British Association for the Advancement of Science, which is to take place this year at Sheffield, beginning on August 31, under the presidency of the Rev. Professor T. G. Bonney, F.R.S., the following presidents have been appointed to the various sections: Section A (Mathematical and Physical Science), E. W. Hobson, F.R.S.; Section B (Chemistry), J. E. Stead, F.R.S.; Section C (Geology), Professor A. P. Coleman, Ph.D.; Section D (Zoology), Professor G. C. Bourne, D.Sc.; Section E (Geography), Professor A. J. Herbertson, Ph.D.; Section F (Economic Science and Statistics), Sir H. Llewellyn Smith, K.C.B.; Section G (Engineering), Professor W. E. Dalby, D.Sc.; Section H (Anthropology), W. Crooke, B.A.; Section I (Physiology), Professor A. B. Macallum, F.R.S.; Section K (Botany), Professor J. W. H. Trail, F.R.S.; Section L (Educational Science), Principal H. A. Miers, F.R.S.—The French Association for the Advancement of Science will hold its thirty-ninth annual meeting at Toulouse in August under the presidency of M. Gariel, professor of biological physics in the faculty of medicine of the University of Paris.

COLUMBIA UNIVERSITY has received an anonymous gift of $350,000 for a building for the faculty of philosophy.—A gift of $150,000 for the erection of an administration building and library at the Rensselaer Polytechnic Institute has been made by the Pittsburgh Alumni Association.—The medical school of the University of Pennsylvania has been given $100,000 by an unnamed alumnus to endow a chair to be known as "the Benjamin Rush professorship of physiological chemistry."—Tufts College has been made the residuary legatee under the will of John Everett Smith, and will, it is said, receive on the death of Mrs. Smith the sum of $500,000.